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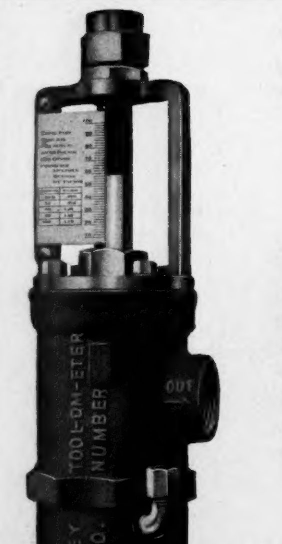
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COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Vol. xxiii JULY, 1918 No. 7

IT'S UP TO ME AND YOU

By Rufus T. Strohm

There's a powerful pile of talkin'
  As to how we're goin' to win,
An' some of it's sound an' full of sense
  An' much of it's weak an' thin;
For it mostly calls on others
  For the help to pull us through,
When the simple truth of the thing is this—
  It's a job for me an' you.

There's a lot of 'em loudly shoutin'
  That an endless line of ships
Will knock the cup of the conqueror
  From the Hohenzollern lips;
An' while I am not denyin'
  That their wish is comin' true,
I'm sartin sure that the final punch
  Will be up to me an' you.

Yet a bunch of 'em keep insistin'
  That our hopes are based on guns,
An' others say that the nation's wealth
  Will defeat the hated Huns,
While some pin faith to our fighters
  In the work they're called to do;
But as for me, I am still convinced
  It's a job for me an' you.

No, we ain't at the front in Flanders,
  Where the blood-red rivers run,
But safe at home in the busy land
  Where the war tasks must be done;
If earth's to be rid of the Kaiser
  An' his dirty Prussian crew,
There's work for a hundred million hands—
  So it's up to me and you.

—American Machinist.

DRY AIR AND COLD STEAM

By Frank Richards

The above title, which has been considered with care and is believed to be not inappropriate, may prove to be at first somewhat misleading, as the article does not deal with the precise conditions of which the normal reader will naturally first think.

The formula for computing the weight of a given volume of dry air at any temperature or pressure is extremely simple. The following gives the weight per cubic foot of dry air throughout the entire range of possible conditions:

$$W = 2.7093 \frac{P}{T}$$

in which W is the weight per cubic foot in pounds avoirdupois, P is the absolute pressure in pounds per square inch, and T is the absolute temperature, Fahrenheit, or the thermometer temperature plus 460 deg.

The above formula may, of course, be easily transformed as follows:

$$T = \frac{2.7093P}{W} \text{ and}$$

$$P = \frac{TW}{2.7093} \text{ or}$$

$$P = 0.3691 \text{ (TW)}$$

0.3691 being the reciprocal of 2.7093.

Table I, compiled by the aid of the above formula, gives the weight of 1000 cu. ft. of dry air for a variety of combinations of temperature and pressure. Tables have been published with minuter intervals and a greater range, but this is thought to be sufficient here.

The diagram, Fig. 1, embodies the same data as in the table, but not for the entire range of temperatures. As all the lines in Fig. 1 are straight lines, this diagram may be indefinitely extended by the aid of a straightedge and pencil.

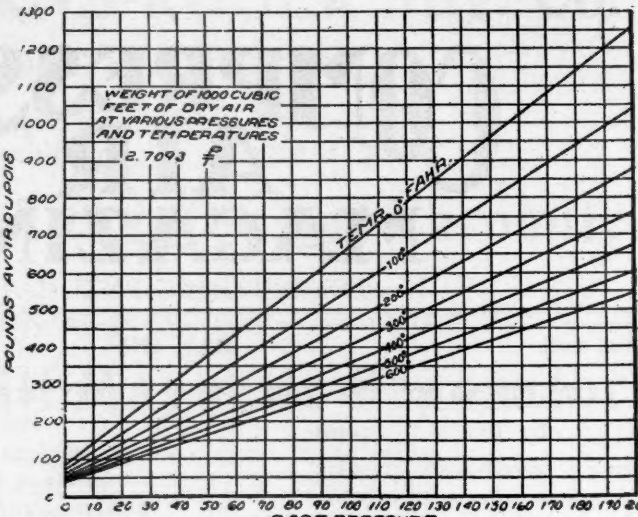


FIG. 1

These dry air data are generally the starting point in computations concerning performance and efficiency in compressed air practice, and there is more than a suggestion of unfairness or irrelevance in their employment. The ideal of efficiency, the 100 per cent. of efficiency, in air compression is generally based, first, upon the assumption that absolutely dry air is used, and second, that the operation of compression is isothermal, or with no rise of air temperature from the beginning to the end of the operation. Now, it happens that both of these assumed conditions are practically impossible, and the computed percentages of accomplishment are compared not with a possible but an impossible 100.

For common manipulation there is no such thing as dry air; and how could there be when we remember that one of the most important and persistent functions of the atmosphere is the conveyance and distribution of water over the earth?

This work of the air is the most familiar topic of our daily conversation. We think of the air as driving over the surface of our sphere and whenever it comes in contact with water picking up some of it, converting it into invisible vapor and flying along with it, until the conditions of pressure and temperature change sufficiently, and then dropping some portion of it, generally in the form of rain. In our familiar talks about the weather, when we believe a rainstorm impending we speak of the air as heavy, or laden with moisture. But the paradox of it is that the more the air is laden with moisture, the greater the proportion of water vapor it carries, the lighter it is, volume for volume; and when, as we say, the air is saturated with moisture it is lightest of all.

The simple fact is that the air does not pick up the water at all; but that the water, when it has the chance, forces itself in among the air molecules, diffusing itself equally all through the air and in the act displacing a portion of the air, so that any volume of moisture-laden air has not all the original volume of dry air in it, but the body becomes a mixture, the volume of air in it being re-

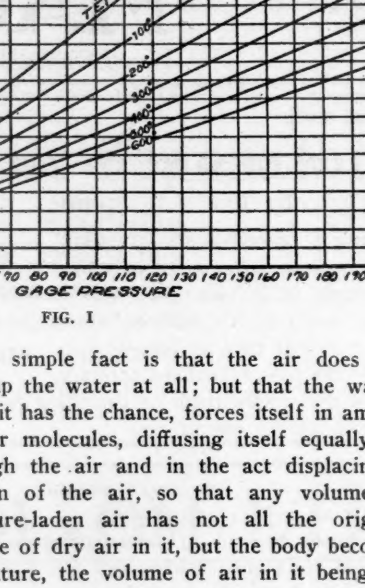


FIG. 2

TABLE I

Temp. Fahr.	Gage Pressure, Pounds																	
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	175	200
0	86.4	145.5	204.0	263.0	321.5	380.0	438.5	497.0	555.5	614.	672	731	790	849	908	968	1114	1260
10	84.6	142.5	199.5	256.8	314.5	372.0	429.2	486.3	543.3	600.6	658	716	774	832	880	947	1090	1233
20	82.8	139.5	195.5	251.6	307.1	364.5	420.5	477.0	533.9	589.0	645	701	757	813	869	922	1067	1208
30	81.1	136.6	191.6	246.5	301.5	357.0	412.1	467.2	522.1	577.1	632	687	742	797	852	908	1046	1184
40	79.5	133.8	187.6	241.5	295.4	350.3	403.8	457.6	511.4	565.2	619	673	727	781	835	890	1025	1161
50	78.0	131.0	183.9	236.7	290.5	343.2	396.0	448.7	501.4	554.1	607	660	713	766	819	873	1006	1139
60	76.4	128.3	180.3	232.3	284.0	336.2	388.2	440.2	492.	544.7	596	649	700	752	804	856	988	1116
70	75.0	126.0	177.0	228.0	279.1	330.2	380.8	431.6	482.4	533.2	584	635	686	737	788	839	967	1095
80	73.6	123.9	173.8	223.7	273.9	324.2	373.8	423.4	472.9	522.4	572	622	673	723	774	824	949	1074
90	72.3	121.8	170.7	219.5	268.8	318.2	367.0	415.4	463.9	512.2	561	611	660	709	759	809	932	1054
100	71.0	119.7	167.6	215.5	263.8	312.2	360.2	407.9	455.5	503.3	551	599	648	696	745	794	914	1035
110	69.8	117.6	164.5	211.5	259.3	307.0	354.2	401.1	448.1	495.0	542	589	637	685	732	780	899	1017
120	68.6	115.5	161.8	208.0	254.9	301.8	348.1	396.4	440.3	486.6	533	579	626	673	720	767	884	1001
130	67.4	113.5	159.0	204.5	250.5	296.6	341.6	392.4	429.6	477.0	524	570	616	662	708	754	869	984
140	66.8	111.5	156.5	201.5	246.5	291.5	336.4	381.3	426.2	471.1	516	561	606	651	696	742	855	968
150	65.2	109.6	154.1	198.5	242.5	286.5	330.8	375.1	419.3	463.6	508	552	596	640	685	730	841	953
200	60.3	101.4	142.7	184.0	224.8	265.5	305.4	347.3	388.2	429.1	470	511	552	592	633	674	776	879

duced, or a portion of it crowded out, and the reduction of air volume being made up by an equivalent added volume of water vapor.

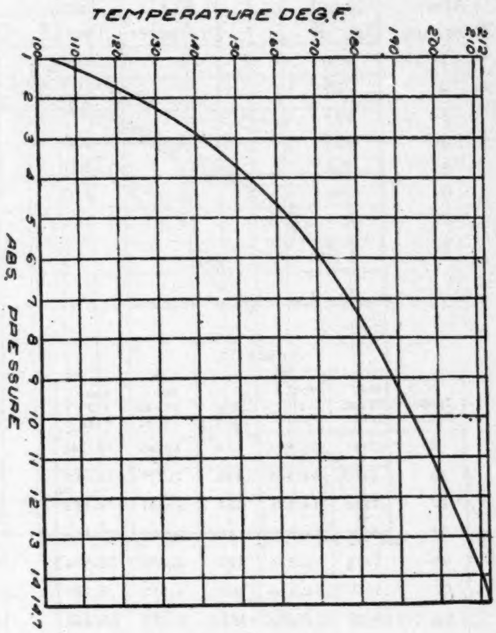


FIG. 3

Here we come in sight of the cold steam of which the title of this article speaks. The water vapor mixed with the air is true steam, produced by boiling or evaporation; and our view of the actual conditions becomes immediately clearer if we agree to consider and to speak of any body of free air, dry air only in name, as a mixture of air and steam.

We speak familiarly of the boiling point of water as something fixed, but water is really as ready to boil at one temperature as at another if it can adjust itself to the pressure conditions. Here is a little list, picked from the steam table in Kent's pocket book, of the ordinary atmospheric temperatures and the absolute pressures at which water boils at these several temperatures.

Temp. Deg. F.	Abs. Pressure	Temp. Deg. F.	Abs. Pressure
32	.089	70	.359
40	.122	80	.502
50	.176	90	.692
60	.254	100	.943

These data are given graphically in Fig. 2. The following is a continuation of the preceding list with the absolute pressures in even pounds.

Abs. Pressure	Temp. Deg. F.	Abs. Pressure	Temp. Deg. F.
1	102	9	188
2	126	10	193
3	141	11	198
4	153	12	202
5	162	13	206
6	170	14	210
7	177	14.7	212
8	183		

Figure 3 embodies the same data.

TABLE II

Temp. Fahr.	Abs. Steam Pres.	Abs. Air Pres.	Temp. Fahr.	Abs. Steam Pres.	Abs. Air Pres.
0	.0215	14.664	112	1.340	13.345
12	.0370	14.648	122	1.777	12.908
22	.0572	14.628	132	2.331	12.354
32	.0889	14.596	142	3.027	11.658
42	.1312	14.554	152	3.891	10.794
52	.1906	14.494	162	4.955	9.729
62	.2728	14.412	172	6.257	8.428
72	.3851	14.299	182	7.836	6.849
82	.5359	14.149	192	9.728	4.955
92	.7367	13.948	202	11.996	2.689
102	.9992	13.686	212	14.685	0.000

TABLE III

Temp. Fahr.	Dry Air	Saturated Mixture	Air in Mixture	Water Vapor in Mixture
0	86.3	86.3	86.2	.077
10	84.4	84.3	84.2	.119
20	82.7	82.6	82.4	.185
30	80.9	80.8	80.5	.279
32	80.7	80.5	80.2	.300
40	79.2	79.1	78.7	.408
50	77.7	77.5	76.9	.584
60	76.3	75.9	75.0	.823
70	74.9	74.2	73.0	1.145
80	73.5	72.5	70.9	1.572
90	72.2	70.8	68.8	2.130
100	70.9	69.1	66.3	2.848
110	69.7	67.3	63.5	3.770
120	68.5	65.5	60.5	4.165
130	67.3	63.5	57.1	6.384
140	66.1	61.3	53.1	8.188
150	65.0	59.0	48.5	10.396
160	64.0	56.4	43.2	13.080
170	63.0	53.6	36.9	16.317
180	62.0	50.4	30.2	21.198
190	61.0	46.9	22.1	24.797
200	60.2	43.1	12.9	30.233
210	59.2	38.8	2.	36.8
212	59.1	37.9	000.00	37.9

In the mixture of dry air and cold, or low temperature, steam which we are considering, the steam retains its own characteristics. It for instance, exercises its elastic force as usual, or produces the resultant pressure due to the temperature. The total pressure of the mixture, therefore, consists of the sum of this pressure added to the air pressure, and does not consist of the air pressure alone.

Table II gives the pressures of both the air and the cold steam, as we are calling it, at various temperatures all the way from 0 to 212 deg. F., the boiling point of water at sea-level atmospheric pressure. The diagram Fig. 4 shows this in an interesting way and should he worth studying. Beginning at zero Fahrenheit, the steam pressure or expansive force is very small, but continually increases with the rise in temperature, the air pressure decreasing correspondingly. At any point, measuring vertically, the sum of the steam pressure added to the air pressure—

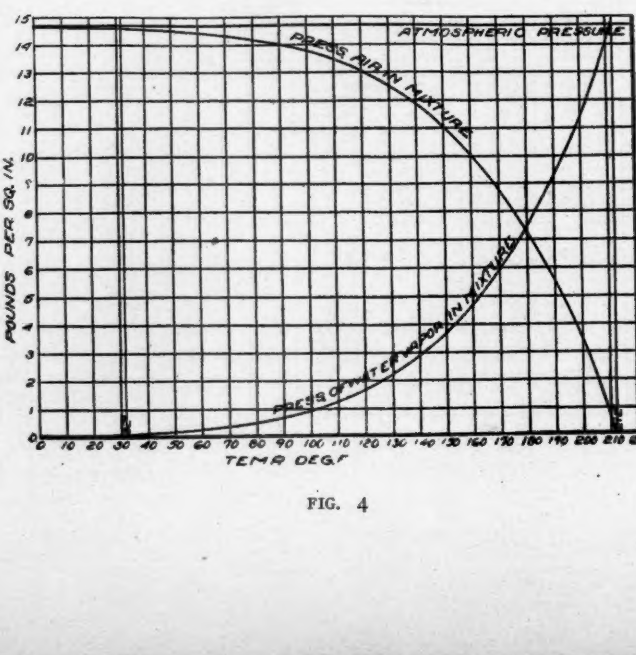


FIG. 4

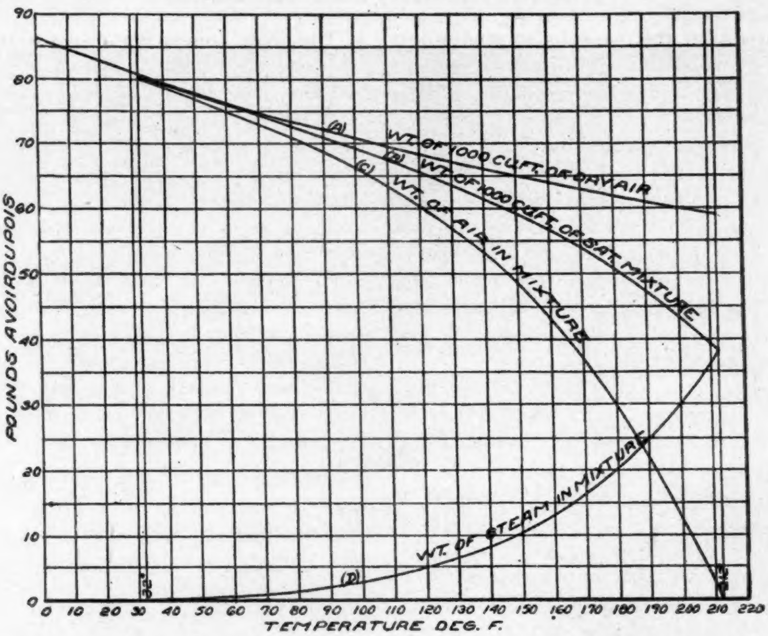


FIG. 5

barring slight inaccuracies in the drawing of the curves—equals the atmospheric pressure.

It is to be remarked all along that the actual constituents of the mixtures tabulated are not the same all through, but are constantly different for the different temperatures. The quantities or weights of both air and steam in saturated mixtures are given in Table III, and are shown graphically in Fig. 5. Referring to the latter, curve A shows the weight of dry air at sea level and at different temperatures; B, the weights of saturated mixtures of air and cold steam; C, the weight of air in the mixture, and D the weight of steam in the mixture, the sum of C and D being always equal to B and always less than A. It is thought that this diagram can sufficiently speak for itself without further explanation.

The word "saturated" in the foregoing connection, suggesting a sponge saturated and heavy with water, is far from satisfactory and as misleading as possible, but nobody suggests anything better.—*Power Plant Engineering.*

And now Birmingham, "the workshop of the world," has begun to turn out ships among its many products; not, indeed, in the completed stage, but in parts which are sent to seacoast localities to be assembled.

HOW THE AIRPLANE PROPELLER DOES ITS WORK

A highly interesting paper upon the above topic has been prepared by Professor Morgan Brooks, of the University of Illinois, for presentation at the June meeting, Worcester, Mass., of the American Society of Mechanical Engineers. The following abstract is from the Journal of the Society.

The term air screw, considered by many writers on aeronautics as descriptive of propeller action, is a misnomer. The theory of the marine propeller, which seems to be adequately presented by the screw principle, has been transferred to air propulsion without sufficient regard for the extreme difference in the two fluids as to elasticity.

In view of the current theory that air is driven by a propeller with a velocity which should not exceed the product of the pitch of the propeller by its revolutions, it was a surprise to find that air may be driven backward at a velocity nearly twice as great as this product indicates. The fact was so revolutionary that it caused the greatest care in measurement before its acceptance. Recognition of this superspeed action of propellers explains many anomalies of air propulsion and will undoubtedly lead to more exact formulae for thrust and power calculations.

The purpose of this paper is to give proofs of the above possibility and to point out some of the applications of superspeed theory as it relates to propellers and blowers.

Superspeed is not readily observant with the standard type of two-blade propeller owing to the masking of this effect by the mingling of high-speed air with a much larger quantity of inert air lying between the propeller blades. Therefore the measurements were made upon a special type of propeller having extremely short blades of great width, sweeping the entire circumference of the disk area.

A propeller of the wide-blade type described having an experimental mean pitch of 2.53 ft. gives a wind on static test that flows 3.33 ft. per revolution, regardless of the speed of the propeller. These values were determined for the writer by Prof. E. P. Lesley at the Leland Stanford, Jr., University wind tunnel, confirming the writer's own measurements. The superspeed ratio, 3.33/2.53, is 1.32, and these figures bear so direct a trigonometrical relation to the blade angle as to suggest that air instead of being swept backward by a screw pressure is driven back by precise reflection or batting action.

The reflection theory is supported by data obtained with a blade of 28 deg. angle and by other confirmatory tests. In this connection an investigation was also made of the more complex condition of a propeller operating in a wind tunnel with wind conditions corresponding to those on a flying plane.

Among other things it was found that for low blade angles, where the superspeed ratio is more pronounced, the air leaves the propeller at higher velocity near the blade tips than part way in, a condition inconsistent with the screw theory for standard-type constant-pitch propellers.

Eiffel in his "Recherches" presents an elaborate collection of data showing that this condition exists, but the reflection theory for the first time explains it.

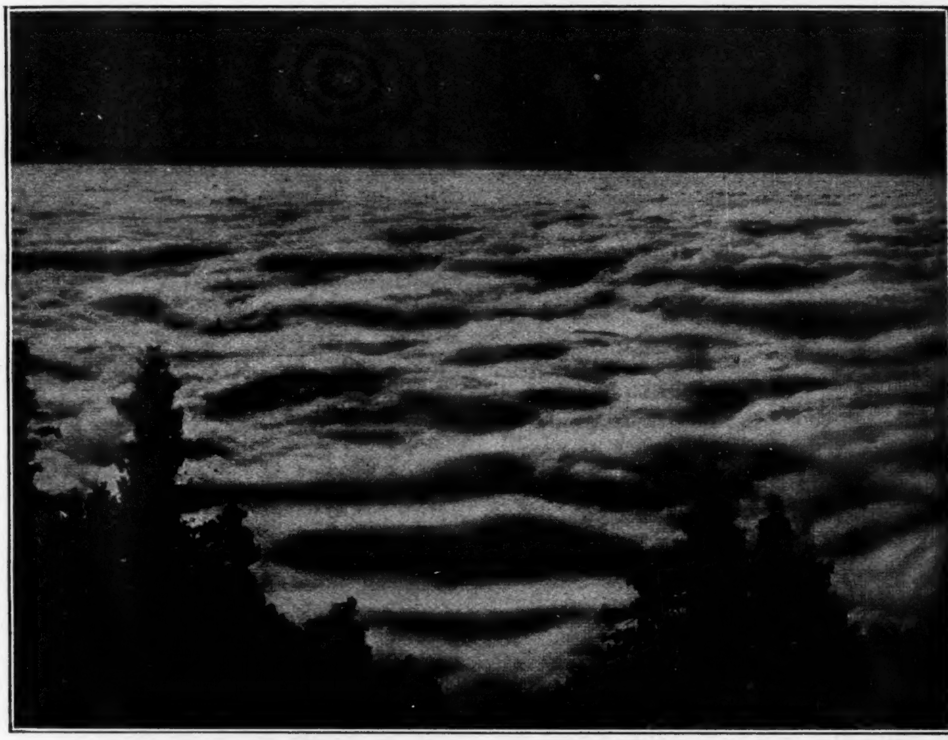
Light ribbons placed in the air flow from a static propeller show that the air moves in a direction strictly perpendicular to the blade angle, a condition determined by the reflection theory but not by screw action. Moreover, these ribbons indicate that the stream contracts slightly in diameter as it leaves the propeller, whereas with the squeezing action of a screw the air would be expected rather to expand.

The most convincing demonstration of the fact that the air leaves a propeller at a greater velocity than the propeller screw advance is found in a test made with two propellers connected in tandem. Calling the forward propeller a blower for the sake of distinction, assume that it provides a wind at 30 miles per hour, or 44 ft. per sec., and that the propeller is driven by this wind at a speed just above idling speed, such that its revolutions times pitch is, say 48 ft. per sec. An anemometer shows a velocity of about 50 ft. per sec., but if the blower be shut down while the speed of the propeller is maintained constant, the wind velocity rises to 75 ft. per sec. instead of remaining constant as demanded by the screw theory.

The acceptance of superspeed action gives a basis for the evolution of dynamic thrust equations without the questionable assumption of blade activity over a larger portion of the propeller disk than that covered by the blades alone. The proper interpretation of superspeed may reconcile thrust and power values as derived from static tests with those of wind tunnels or of flight. Today it seems to be the common opinion that flying performance may not be predicted from static tests. With the precise air-dynamics formulæ sure to be developed, a single static test of a propeller should furnish all necessary data for the production of complete flying-performance curves.

The writer shows analytically that apparently the wind-tunnel blower relieves the propeller of a portion of the static thrust at a given propeller speed represented by idling speed, even though the propeller giving superspeed sends air backward when tested statically at the speed V/p, where V is plane velocity and p the propeller pitch. The writer shows that under his formula the flying thrust at 30 per cent slip is found to be 51 per cent of the static thrust at the given propeller speed.

What is said to be the world's knitting record is claimed by Mrs. Fred Springer, of Detroit, who won a contest conducted by the Red Cross in which there were more than 700 contestants. In two hours Mrs. Springer completed twenty-one inches of a man's sock, the leg, heel and three-fourths of the foot. This of course is not comparable with the shipbuilding riveting record.



ADVECTION FOG, SEEN FROM MOUNT WILSON, CALIFORNIA

FOGS*

In general a fog differs from a cloud only in its location. Both are owing to the cooling of the atmosphere to a temperature below its dew-point, but in the case of the cloud this cooling usually results from vertical convection, and hence the cloud is nearly always separated from the earth, except on mountain tops. Fog, on the other hand, is induced by relatively low temperatures at and near the surface, and commonly itself extends quite to the surface, at least during the stage of its development. In short, fog consists of water droplets or ice spicules condensed from and floating in the air near the surface; cloud, of water droplets or ice spicules condensed from and floating in the air well above the surface. Fog is a cloud on the earth; cloud a fog in the sky.

*From "Physics of the Air" by W. J. Humphreys, Professor of Meteorological Physics, United States Weather Bureau, in Journal of Franklin Institute.

According to the conditions under which they are formed, fogs may be divided into two general classes—radiation fogs and advection fogs.

RADIATION FOG

Fog is likely to form along rivers and creeks and even in cleared mountain valleys during any still, cloudless night of summer and, especially, autumn. In the course of a calm warm day much water is evaporated into the lower atmosphere of such regions, where in large part it remains as long as there are no winds. Hence this air, because it is humid, and the adjacent surface of the earth lose much heat during the night by radiation to the clear sky. In many cases they cool in the end to a temperature below the dew-point, and thus induce a greater or less volume condensation on the always-present dust motes that results in a correspondingly dense fog. Such fog, however, is not likely to occur during cloudy nights, because the air seldom then cools sufficiently, nor during high winds, since they dissipate the humidity and

also through turbulence prevent the formation of excessively cold aerial lakes.

The distinctive factor in the formation of this type of fog is the free radiation of the ground and the lower air by which the latter is sufficiently cooled to induce condensation. Hence fogs formed in this manner are properly termed "radiation fogs," sometimes also called "land fogs" and "summer fogs."

ADVECTION FOG

Whenever warm, humid air drifts over a cold surface its temperature is reduced throughout the lower turbulent layers by conduction to that surface and by mixture with remaining portions of the previous cold air and a correspondingly dense fog produced. Hence fog often occurs, during winter, in the front portion of a weak cyclone; also whenever air drifts from warm water to cold—from the Gulf Stream, for instance, to the Labrador Current; and wherever gentle ocean winds blow over snow-covered land—circumstances that justify the terms "winter fog" and "sea fog" (drifting on shore in places, and even some distance inland. Similarly, a cold wind drifting or spreading under and through a body of warm, humid air also produces a fog, though usually a comparatively light one. This explains the fog that frequently forms, during winter, along the front of a "high," and the thin fog that occasionally is seen over lakes on frosty autumn mornings, when the water appears to be steaming—actually evaporating into air already saturated and thus inducing condensation. It also explains the frequent occurrence of "frost smoke" on polar seas.

If the wind is strong the turbulence extends through a comparatively deep layer. Hence in the case of warm air drifting over a cold surface if the movement is rapid the total duration of contact between any portion of the air and that surface is likely to be so brief that but little cooling can take place and no fog be formed. Similarly, it ususually also happens that fog does not form when the cold wind blowing over a warm, humid region is even moderately strong. Here the turbulence mixes the excessive humidity near the surface through so large a volume that saturation commonly is not produced, nor, therefore, any trace of fog.

From the above it appears that all fogs that result from the drifting of warm, humid air over cold surfaces, as also those that are produced by the flow of cold air over warm, humid regions, are but effects of temperature changes induced by the horizontal transportation of air; hence the proposed general name, "advection fog." The term advection is preferred to convection because the latter is practically restricted, in meteorological usage, to a change of level, whereas in the case under consideration only horizontal movements are concerned. The contradistinction, therefore, between "advection fog" and "convection cloud" is obvious, and, presumably, worth while.

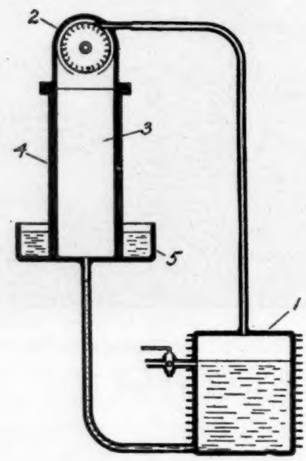


FIG. I

POWER FROM THE HEAT OF THE ATMOSPHERE

By Perry Okey*

As expressed by Clausius—"Heat cannot of itself pass from a colder to a hotter body," and by Lord Kelvin—"It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of surrounding objects." The second law of thermo-dynamics has been generally understood to mean that work may not be obtained from the inherent heat of the atmosphere.

Although these statements apparently have

*Journal American Society of Mechanical Engineers.

been mathematically demonstrated, the mind nevertheless rebels against a law which denies the possibility of using any portion of the thousands of millions of horsepower existing at all times in the atmosphere. Such mental rebellion led the writer to attempt the utilization of this energy in spite of what is declared to be the second law of thermodynamics.

The result of this effort, which thus far has been imaginative rather than through mathematical treatment, seems to indicate several methods by which work may be realized from the heat in the air.

A simple apparatus which demonstrates the fact has been constructed and operated by the writer and will be understand by referring to Fig. 1. This apparatus consists of but three essential elements, viz., the boiler 1, the turbine 2, and the condenser 3. A pipe connects the top of the boiler to the nozzle of the turbine and the casing of the turbine opens directly into the condenser. The condenser is provided with means for evaporating water from its outer surface. In the sketch this is shown as a fibrous covering 4, which keeps moist by drawing water from the receptacle 5 by its capillarity. A pipe connects the bottom of the condenser to the bottom of the boiler.

The operation will be most easily understood by assuming the plant completed and ready for starting. The first act is to exhaust the air from the entire system through the valve in the boiler. A quantity of liquefied gas sufficient to partly fill the boiler is next introduced through the same valve, which is then closed. Finally the receptacle at the bottom of the condenser is filled with water.

The heat interchanges or cycles, of which there are two, commence as soon as evaporation of water takes place from the exterior of the condenser. The water, in the act of evaporating, removes an increment of heat from the condenser, causing a reduction in temperature and consequently a condensation of the vapor therein. This, in turn, brings about a difference in pressure between the condenser and the boiler which is available for operating the turbine. The condensate from the condenser enters the boiler at a temperature lower than that of the atmosphere, which enables the boiler to absorb an amount of heat from the atmosphere equivalent to the amount rejected by the condenser to the atmosphere less the amount converted into work. The difference of level between the liquid below the condenser and that in the boiler serves in place of a pump for feeding the boiler.

The little plant shown in Fig. 1 has been running continuously for some time, using sulphur dioxide as the working fluid. It will be seen that the capacity of the plant is a function of the relative humidity of the atmosphere, being greater in a dry climate than in one of more humid character. Operation would cease when the relative humdiity reached 100 per cent, or when the temperature fell to 32 deg. fahr.

That the mechanism operates at all is due to the fact that nature, in the course of her unending processes, is continuously depositing moisture out of the air, rendering it again capable of absorption in the manner and with the result described. If we were compelled to remove the moisture content, no doubt the work cost would balance the work derived, but if nature does this work without cost to us, it would seem that, as far as our interests are concerned, mechanical work may actually be derived from the heat in the air. Furthermore, it appears that under these conditions and through the agency of evaporating water, heat does in fact pass from a cold body to a hotter medium, for the heat from the cold condenser is rejected to a hotter atmosphere.

If these conclusions are correct—and they must be, since the machine runs—then the statements of Clausius and Kelvin are not strictly true.

The efficiency of the cycle, based on the standard of Carnot, is low, but it may even be that the Carnot cycle itself is not the final word in heat efficiency.

The question as to commercial possibilities has been asked, and after a careful study of the matter the writer is convinced that no commercially successful results may be hoped for, although remarkable performances might be realized if no attention were paid to investment costs.

The noncompressibility of water, coupled with the thickness of some men's heads, has helped the repair shops to several millions of dollars of work. We cannot change the nature of water, but we can do something with the men's heads.—*Marine Engineering.*

TABLE I—APPLICATIONS TO WHICH SYNCHRONOUS MOTORS ARE ADAPTED

TYPES OF PLANTS USING SYNCHRONOUS MOTORS AND THE MACHINES WHICH ARE DRIVEN →	AIR COMPRESSORS	AMMONIA COMPRESSORS	CENTRIFUGAL PUMPS	CONVEYORS	CRUSHERS	FANS	FREQUENCY CHANGERS	GRINDERS	JORDANS	LINE SHAFTS	MIXERS	MOTOR GENERATOR SETS	PULP GRINDERS	RECIPROCATING PUMPS	ROLLS	SCREW PUMPS
AUTOMOBILE PLANTS	■						■			■		■				
BRICK AND CLAY PLANTS			■	■		■										
DRAINAGE PLANTS			■				■									■
ELECTRIC LIGHT AND POWER PLANTS							■					■		■		
FLOUR MILLS										■						
FOUNDRIES	■											■				
ICE AND REFRIGERATING PLANTS		■										■				
IRON WORKS	■						■					■				
IRRIGATION PROJECTS			■													
MINES			■			■						■				
MARBLE AND STONE CUTTING PLANTS								■		■						
METAL WORKING PLANTS										■					■	
OIL REFINING PLANTS			■									■				
PAPER MILLS									■			■	■			
QUARRIES	■				■											
RUBBER MILLS										■		■			■	
RAILROAD SHOPS	■									■						
SHIPYARDS	■											■				
STEEL PLANTS	■											■				
SUCTION DREDGES			■													
SEWAGE DISPOSAL PLANTS			■									■				■
STONE CRUSHING PLANTS				■						■						
TEXTILE MILLS										■		■				
WATER WORKS			■											■		
MISCELLANEOUS	■	■	■			■	■			■		■		■		

ADAPTABILITIES OF SYNCHRONOUS MOTORS

By Will Brown*

Synchronous motors cannot be used profitably on small loads. This generally means anything under 100 hp. An exception should be made in the case of small synchronous motor-generator sets, however. They cannot be used on intermittent loads involving frequent starting and stopping, such as crane motors, reversible hoist motors, etc. They cannot be used where variable speed or adjustable speed is demanded unless some mechanical means of regulating the speed change is provided. They cannot be used where it is necessary to start up the full load from rest unless a clutch or some other mechanical method of easing the starting condition is supplied.

Where synchronous motors may be, and are actually, employed is attested by Table 1. It does not by any means cover the full field of possible applications, but it does indicate the already wide range of these motors and the promise of a much greater use in the future.

Where a heavy and fairly continuous load can be driven at a constant speed, there is generally an opportunity to install a synchronous motor. High efficiency and reliability of service are the two great essentials in such work. It is safe to say that a synchronous motor is always higher in efficiency than an induction motor of corresponding rating. At low speeds the advantage in favor of the synchronous motor is even greater than at high speeds.

There are many heavy-duty machines which must be run at low speeds. Formerly, if these machines were to be driven by motors it was necessary to install some form of belt or gear drive. They can now be directly connected to synchronous motors and operate efficiently at speeds as low as 72 r.p.m.

STARTING ABILITY

The old handicap of synchronous motors was their inability to start up from rest while carrying a mechanical load. This handicap has been overcome to a greater extent than most engineers realize. There are practical examples of large synchronous motors developing a starting torque as high as 50 per cent. of full-load torque obtained without a prohibitively large kva. input. The future will probably bring even more remarkable results.

It is a fundamental fact that a low-speed synchronous motor cannot develop as high an initial starting torque with the same starting voltage as the high-speed motor, it being understood that horsepower ratings of the two motors are the same. For example, a certain motor with a synchronous speed of 200 r.p.m. can develop a starting torque of 35 per cent. of full-load torque on the 40 per cent. voltage tap with an input of 130 per cent. of the full-load kva., whereas a 600-r.p.m. motor can de-

*Condensed from Electrical World.

velop a starting torque of 40 per cent. of full-load torque on the 40 per cent. voltage tap with an input of 115 per cent. of full-load kva.

VARIABLE LOADS

Many types of heavy-duty machines requiring variable output are now designed so that they can be started and driven by synchronous motors. For instance, in a certain reciprocating pump installation a variable stroke is automatically obtained by means of bell cranks and by shifting the cylinder. This permits varying the delivery from zero up to 4200 gal. per minute.

Mechanical methods for changing the inlet or outlet passages for fans and blowers permit the use of constant-speed motors where formerly only adjustable speed motors could be used. There are already a number of such installations—for instance, large exhaust fans such as are used on mine shafts, etc.—and it seems quite likely there will be many more in the future.

EFFICIENCY AND RUGGEDNESS

The high efficiency which can be secured with a synchronous motor is well illustrated in the following installations: One marble-working concern has been operating a 150-hp. synchronous motor driving a line shaft for nearly four years. The choice originally lay between an induction motor and a synchronous motor. The higher efficiency obtained by the synchronous motor brought a saving in the first two years of operation which more than made up for the higher original cost of the synchronous motor.

There is a rather interesting installation in a paper mill where a 1150-hp. synchronous motor is driving two direct-coupled pulp grinders. No difficulty has been experienced either in starting or running. An induction motor of similar horsepower driving a similar load has caused more or less trouble, which is generally traced to the very small air gap. The slightest wear in the bearings alters the air gap sufficiently so that very heavy magnetic pull is set up on one side of the rotor and quickly wears the bearings down still more until the time arrives when the motor must be stopped and the bearing repaired. Very frequently the windings of the armature are damaged also. The synchronous motor, owing to its comparatively large air gap, is much more rugged and dependable for operation on low speed, direct connected loads.

DRIVING AIR COMPRESSORS

Air compressors, especially those of sufficiently large capacity to require 100 brake horse-power or more, can be economically and efficiently driven by synchronous motor. The old idea that it was necessary to change the piston speed with change in air demand has been abandoned. Mechanical methods of regulation on the compressors now permit the driving motor to operate at a uniform speed.

In practice synchronous motors are used bolt belted and direct connected to the compressor. On direct connected units the speeds required are generally within the range of 260 r.p.m. down to 120 r.p.m. Probably the greatest number of direct connected synchronous-motor-driven compressors operate at a speed in the neighborhood of 200 r.p.m. This speed is very much higher than was ever thought advisable by compressor builders a few years ago. The increased speed has been made possible by the adoption of a light plate valve with a low lift. The time required to open and close such a valve is so small that it permits operating the piston at much higher speeds.

TABLE II—EFFICIENCY AND POWER-FACTOR TESTS OF 560-HP., 225-R.P.M. SYNCHRONOUS MOTOR DIRECT-CONNECTED TO AIR COMPRESSOR

Exciting current remaining constant at all loads

	Quarter Load	Half Load	Three-Quarters Load	Full Load	One-and-a-Quarter Load
Efficiency	92.6 per cent	95.6 per cent	96 per cent	96 per cent	95.4 per cent
Power factor	73 per cent Leading	93 per cent Leading	98 per cent Leading	100 per cent	98 per cent Lagging

In starting an air compressor the pressure can be relieved by a by-pass, so that the motor has only the friction load and inertia to overcome in breaking the compressor from rest. This is very easily taken care of without drawing excessive kva. from the line, and the motor can pull into synchronism without causing objectionable fluctuation of the line voltage.

Since the load factor of a compressor is generally high, and since the power factor of a synchronous motor can be maintained at unity, a favorable rate can usually be secured when energy is purchased from a central station. The fact that these motors operate at unity power factor or slightly leading (at part loads) should appeal with even greater force to plants generating their own energy. the power factor and efficiency obtained with a typical direct connected synchronous-motor-driven air compressor are shown in Table II.

Recently there has been an enormous demand for large synchronous-motor-driven air compressors among the shipyards of the country. They range in size from 150 hp. to 1200 hp. Among other lines of industries using these machines might be mentioned mines, foundries, automobile factories, structural steel works; in fact, any industry where a large quantity of compressed air is used. In driving tunnels the air pressure can be maintained in the headings by means of a battery of low pressure compressors driven by synchronous motors.

AMMONIA COMPRESSOR DRIVE

The large ammonia compressors used in ice plants (50 ton or over) are driven, in exactly the same way as air compressors, by either belted or direct connected synchronous motors. The starting duty required is, however, somewhat more severe than in the case of ordinary air compressors. In order to obtain the required starting torque it is sometimes necessary to use a higher voltage tap on the starting compressor than would be necessary with the corresponding air compressor installation. The large flywheel combined with the inertia and friction of other moving parts requires that the motor be specially designed to produce maximum starting torque.

The preference for direct-connected synchronous-motor-driven ammonia compressors is very markedly shown in the ice and refrigerating plants recently constructed or now in course of construction. It may be said safely that the energy cost with direct-connected synchronous-motor-driven machines is less per ton of ice manufactured than is the case with any other type of motor drive.

Once it was considered essential, in order to meet the varying demands for ice, that the speed of the ammonia compressors should be adjustable. This is no longer necessary. In place of one large unit running at variable speeds, ice plants can have two or more smaller units which run at constant speed. By running different combinations of the compressors in parallel, fluctuation in demand can be easily cared for without provision for speed adjustment. When the demand drops to a minimum the smallest compressor only may be used, so the losses may be kept at the minimum. It can be seen that the over-all efficiency of such a plant will be very much higher than in the old-fashioned variable-speed plant.

Another method of varying the output of the compressor at constant speed is by means of an adjustable clearance pocket, or cylinder, at each end of the compression cylinder. By

TABLE III—EFFICIENCY AND POWER-FACTOR TESTS OF 450-HP., 200-R.P.M. SYNCHRONOUS MOTOR DIRECT-CONNECTED TO AMMONIA COMPRESSOR

Exciting current remaining constant at all loads

	Quarter Load	Half Load	Three-Quarters Load	Full Load	One-and-a-Quarter Load
Efficiency.....	87.7 per cent	92.6 per cent	93.7 per cent	94 per cent	93.8 per cent
Power factor.....	70 per cent Leading	94 per cent Leading	99 per cent Leading	100 per cent	99 per cent Lagging

means of these the clearance can be increased and the capacity lowered to any desired point between full load and one-quarter load or even lower. Thus the flexibility of the compressor is fully equal to that of the old adjustable-speed compressors driven by low-speed Corliss engines.

The efficiency curve of the synchronous motors is quite flat throughout a wide range of load, so that there is very little loss in efficiency on the part of the motor when run at part loads. As far as the compressor is concerned, the efficiency at part loads seems to be practically as good as at full load. This is due to the general conditions under which ice-manufacturing plants operate. The efficiency, power factor and starting torque for a typical synchronous-motor direct connected to an ammonia compressor are indicated in Table III.

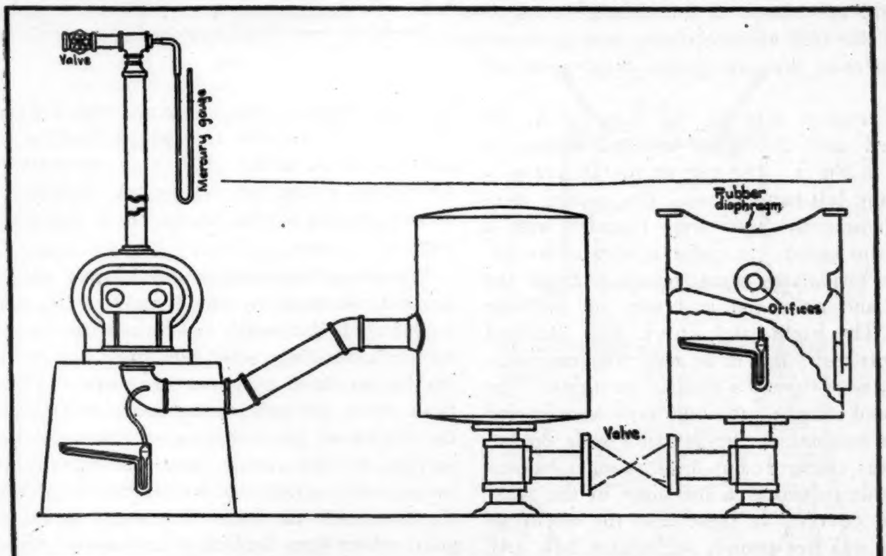


FIG. I

MEASURING AIR DELIVERY OF ROTARY BLOWERS

For the purpose of investigating various theories, Professor W. Trinks of the Carnegie Institute of Technology has made an interesting series of tests of a rotary blower built by the P. H. & F. M. Roots Company, Connersville, Ind.

Tests to determine the volume of gas delivered by centrifugal exhausters are more easily and more frequently made than the corresponding tests of rotary exhausters, because the discharge of the latter is pulsating. Nozzles or orifices cannot be used to measure pulsating flow unless the pulsations are eliminated. These tests are seldom performed on rotary exhausters chiefly because every rotary exhauster is a meter of the displacement type, so that the speed of the exhauster is a measure of the quantity of gas delivered. A definite quantity of gas is imprisoned during each cycle and delivered positively, except for the leakage or slip. The latter is constant regardless of speed, depending only upon the inlet and outlet pressures, and upon the density of the gas being exhausted.

In each rotary exhauster there is a speed, commonly referred to as the slip, at which the leakage accounts for all of the gas handled by the exhauster. Above this speed the exhauster delivers its full displacement to the discharge system. The probable delivery, therefore, is found by multiplying the difference between the slip speed and the actual speed by the displacement of the exhauster per revolution. Evidently, the volumetric efficiency increases with the speed. When the speed of the exhauster is 10 times the slip speed, the volumetric efficiency is 90 per cent. Some operators of rotary blowers and exhausters believe that other factors enter into the rate of delivery. The belief is rather gen-

eral that pressure drop due to friction in the intake pipe reduces the delivery and counteracts the increase in efficiency due to the higher ratio of actual speed to slip speed.

The arrangement of the testing apparatus employed by Prof. Trinks is shown in Fig. 1. The air from the blower enters the right hand tank through standard nozzles. This tank is closed at the top by a thin rubber diaphragm the mass of which is so small that it vibrates with the pulsations of the air in the intake pipe and maintains practically a steady flow of air through the nozzles. When the blower is in operation the oil in the draft gage near the blower vibrates with the pulsations in the air column, while the oil in the draft gage at the measuring tank is motionless. The water seal at the extreme right in Fig. 1 saves the rather expensive rubber diaphragm in case the blower is started with all the nozzles closed. The intermediate tank between the measuring tank and the blower is not absolutely necessary in this test, because the vacuum produced is not greater than the rubber diaphragm will allow.

The relation between the quantity of air delivered and the speed of the blower is shown in Fig 2. The test of the blower produced the left-hand curve. The results were so surprising the tests were repeated with a larger slip speed. In order to obtain the latter the headplates were removed from the blower and more red lead was put into the joint. The right-hand curve was obtained from this test. It will be seen that the character of both curves is exactly the same. The length and shape of the inlet pipe were varied and the location of the pressure gage on the outlet was changed; but these changes had no appreciable influence on the shape of the characteristic curves. In these tests the discharge pressure was five pounds per square inch. At lower pressures the slip speed is much less.

The actual delivery falls below the probable delivery at lower speeds and rises above it at higher speeds. Vibrations of the air column undoubtedly explain this peculiarity. At low speeds the whole column is accelerated and retarded, but as the speed increases the inertia of the column causes vibrations of a sound-wave character to appear. At certain speeds, the phase of these vibrations corresponds with the opening of the blower to the suction and an extra quantity of air is shoved

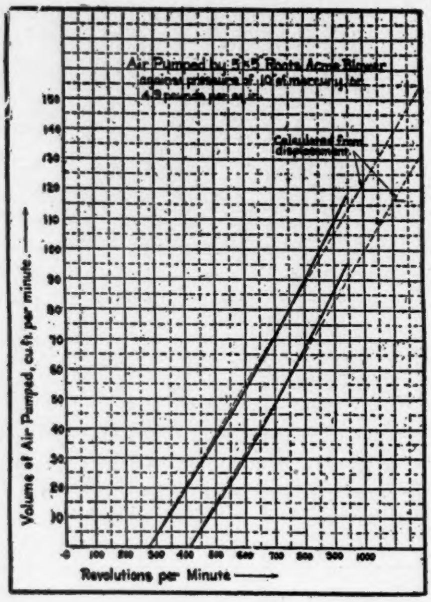
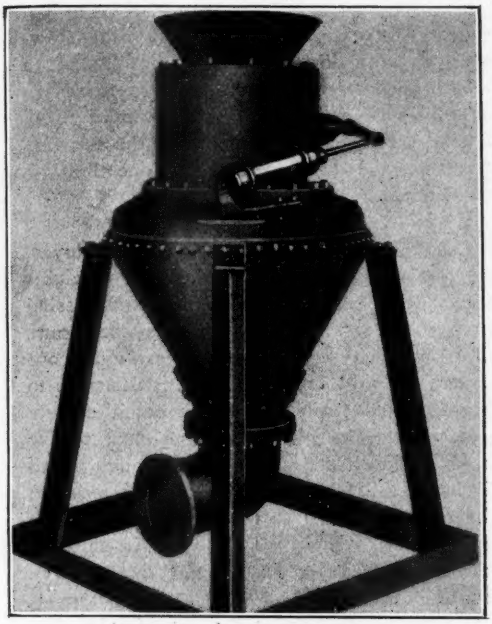


FIG. 2

into the blower, thus increasing the delivery. This case is parallel to that of blowing engines with air-intake pipes and automatic-inlet valves where the delivery is likewise increased by the inertia of the air in the intake pipe.

Vibrations have a phase-lag against the impressed vibration of the blower. This may explain why attempts to furnish an engine torque coinciding with the static torque of the blower have not been successful. Vibrations occur not only in the intake but also in the discharge pipe. It has been thought that perhaps at high speeds these vibrations might become destructive. It is true that vibrations increase with the speed but only up to the point where they become sound-waves. Above this speed the pitch of the sound, i. e., frequency of vibration, increases; but the amplitude, i. e., loudness, remains constant. The maximum vibration depends upon the ratio of outlet-pipe size to fluctuation of displacement. The smaller the outlet pipe for a given blower, the worse the vibration becomes. With the average size of outlet pipe the vibration to either side from mean does not exceed 10 per cent. of the absolute average outlet pressure. In unusually long pipes, however, resonance might increase this somewhat.



CONCRETE MIXER

DETAILS OF PNEUMATIC CONCRETING

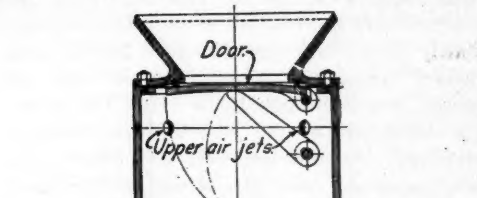
By H. B. Kirkland*

The pneumatic method of mixing, conveying and placing concrete is a comparatively recent development in engineering methods of construction. This method should not be confused with the cement gun process, which is a plastering process and is entirely different in operation and purpose. Both methods are patented. The pneumatic method is adapted for heavy, difficult concrete work, using ordinary ingredients with aggregates up to 4 or 4½ in. diameter.

Briefly described, this method consists simply in blowing batches of concrete through a pipe from a central point of supplies to their place in the concrete forms. The materials for a batch of concrete (1½ cu. yd.) are proportioned in a measuring device and dropped into the pneumatic mixer without previous mixture.

EQUIPMENT

The plant for pneumatic mixing and placing consists of a mixer, a pipe conveying system and a compressed air plant. The mixer consists of a steel shell having the shape of an inverted cone surmounted by a cast steel cylinder in which a door is operated by a small air piston. The door is opened by releasing the air in the cylinder, allowing it to drop open by its weight. At the bottom of the inverted cone chamber is a 90-deg. elbow which forms the connection to the discharge pipe. The door and piston is the only moving part of the mixer and the inside contains no mechanical mixing apparatus and is entirely smooth and free from obstructions. An air jet located at the heel of the bottom elbow of the mixer is the prime means of conveying and mixing the concrete. It is supplemented by other air jets located at the top of the mixer. The main air jet is directed into the center of the discharge pipe where it catches the material as it falls from the cone-shaped hopper above. The upper air jets create a pressure from above the batch, forcing it downward into the discharge pipe where it is caught by the main jet. To admit air to the mixer, two valves are used, one located on the air supply



CONCRETE MIXER IN SECTION

*Abstract, Western Society of Engineers.

line leading to the lower jet and the other on the line leading to the upper jets placed above the level of the batch.

THE OPERATION

In operating, after the batch containing cement, aggregate and water is placed in the mixer, the door is closed and the main jet is opened. This is followed by opening the valve to the upper air jets. Many operators very this method but the effect of this sequence of control is to start the batch forward at the bottom of the machine, detaching successive portions of the batch at the tip of the cone. The materials in the mixer flow downward in the same manner that sand flows from the upper chamber of an hour-glass, but the speed of the flow is accelerated by the air pressure.

The conveying pipe consists of any standard smooth steel pipe with joints made with bolted flanges or any type most easily and rapidly handled in making connections. The most rapid wear on the pipe occurs at the points where there is apt to be a slight irregularity or a shoulder. Threaded pipe is also thinner where the threads are cut and of course wears through there first. For making deflections of the pipe line, cast elbows are used. An ordinary cast iron elbow will last sometimes less than a day, but a case-hardened steel elbow will usually last a few weeks. The best elbow is cast manganese, which will almost outlast the pipe itself. These elbows are made in 45 deg. with a thickness of 5/8 in. on the inner curve and 7/8 in. thickness on the outer curve. This gives a weight of about 220 lb. for an 8-in. elbow. The radius of the elbow is 3 ft. minimum, as a shorter radius is too sharp a turn and causes plugs in the line. Shorter radius elbows may be used however, at the discharge end of the pipe. A split elbow of 90 deg. has also been used for 6-in. pipe. This elbow is split lengthwise so that the outer half of the curve which usually wears rapidly may be replaced.

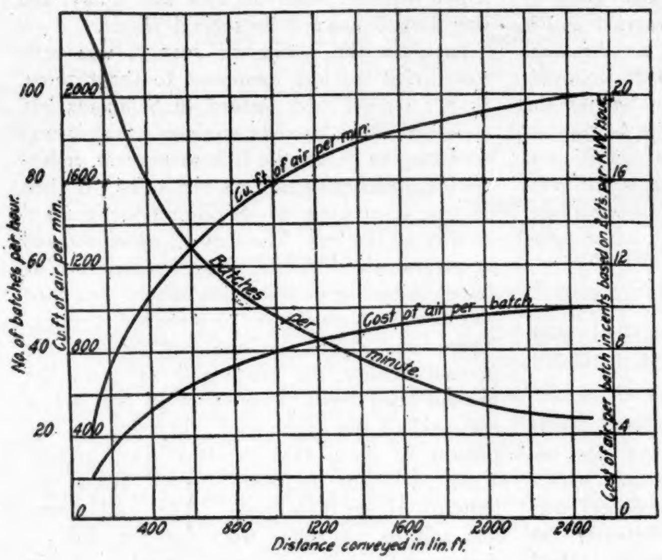
A means of deflecting or guiding the discharge of concrete in the forms consists of a series of slightly tapered pipes, fitting together like stovepipe. Two or three sections of this light pipe about three or four feet long are all that are needed in a tunnel form for diverting the discharge from one side wall to the other and for guiding the concrete discharge around points of rock projecting from the roof. Where the tunnel is very wide, however, as in a double track railroad tunnel, a wye branch is used in the line, so there are two lines of pipe entering the tunnel form. A side valve or gate is placed in the wye for diverting the batches through one line or the other.

THE COMPRESSOR

A compressor of suitable type is employed, the one ordinarily selected being a straight-line, one-or-two-stage machine, compressing from 80 to 125 lb. The drive may be steam, oil or electricity as may be cheapest, most convenient, or most economical. It is desirable to locate the plant near the mixer, but it is quite necessary to provide air storage close to the mixer sufficient at least to store enough air to discharge a batch of concrete at the maximum distance required. This storage should be at least 100 ft. capacity with 30 cu. ft. capacity added for each 100 ft. of pipe line. There should be additional storage at the compressor if the mixer is located a considerable distance away (for example, more than 300 ft. away).

The amount of air required to convey concrete depends upon the specific gravity of the materials, the smoothness of the pipe, the number of bends in the pipe line and their radii, the distance conveyed vertically and horizontally and upon the pressure or velocity of the air used. For the standard size mixer this is about 2 cu. ft. of actual free air compressed to 100 lb. per sq. in. per lin. ft. of pipe per batch. In other words, to convey one batch 500 ft. it will take 1,000 cu. ft. of actual free air compressed to 100 lb.

Based upon this figure, the diagram shows the amount of air required to convey concrete at various distances. This curve is based upon practical observations on a number of jobs, and certain assumptions have also been made in order to complete the figures. It is assumed in this curve that certain conditions of the concrete operations are as follows: 20 sec. are allowed for opening the door and charging the mixer after each batch has been discharged and the air valves closed; 5 sec. are taken as the length of time to convey a batch each 100-ft. and as the distance becomes greater the number of batches per hour decreases until at 2,500 ft. the number is 24, and the amount of air at this distance is 2,000 cu. ft. per min. It should be borne in mind that



AIR REQUIREMENTS FOR CONVEYING CONCRETE

if it is desired to get the maximum output possible the capacity of the compressor should be great enough to build up the air pressure in the storage tank in the time required to shoot a batch.

THE MIXING PROCESS

One of the first questions asked by the engineer is, "How is the concrete mixed?" This is explained by a study of the conditions which affect the batch from the time it is placed in the mixer until it is delivered in place in the forms.

In loading the mixer the ingredients, cement and water, are usually placed in a measuring hopper, so that when the hopper is emptied into the mixer the first commingling of the ingredients takes place. The first commingling is not particularly important, as it is very slight. When the air is turned on that portion of the batch which is at the bottom of the mixer, in front of the conveying air jet, is first to move and is instantaneously followed by portions dropping from above. As the mixer has the shape of an hour glass, the central portion of the batch in the mixer flows down first, and the portion in the sides follows in the stream from the upper part, exactly as sand flows in an hour glass. During this operation the mingling of the different ingredient parts causes the smaller ingredients to flow into the voids between the larger ingredients. As the portions of the batch drop into the lower air stream, which has a velocity of about 5,000 ft. per sec., these portions are carried along in suspension much as dust is carried along in a storm, except that the particles are much closer together. Although the speed of the air jet is very high, the speed of the concrete materials is much lower. The speed of the concrete varies according to the amount of voids in the materials which permit the air to pass through. The air in passing through tends to carry with it the smaller ingredients; that is, the sand tends to fill the voids between the rocks and the cement tends to fill the voids remaining, and, as the voids become filled up with the smaller ingredients passing through, the speed of the mass increases, the pressure of the air behind the mass increases with the decrease of the voids in the mass, and the speed of the mass concrete increases.

Now, in this explanation of the mixing process, I have assumed that the air velocity passing through the pipe is sufficient to keep the materials in suspension, and it is important to have a sufficient air pressure to keep the materials in suspension, because when the air velocity is reduced the materials simply roll and tumble along the bottom of the pipe. The concrete will also mix in this manner, but it is not conducive to good operation and makes a dirty pipe line, which is liable to become plugged. In shooting concrete, therefore, it will be found that with an 8-in. pipe and with materials of the specific gravity of limestone, the pressure should not fall below 50 lb. per sq. in., as the materials will then commence to drag along the pipe. Any air expended below 25 lb. is wasted when blowing concrete through an 8-in. pipe.

Three general types of pneumatic installations have been developed through the requirements of different classes of work. These are central plant or scheme of locating the mixer at a central point from which the conveyor

pipe is laid to the forms, portable plant or outfit upon which the mixer is carried and is either loaded from bins carried on the same conveyance or supplied by a belt or other loading device, and the scheme of loading the mixer at various points as at the bottom of manholes in shallow tunnels and supplying it with materials through a chute from the various corresponding points along the surface. The last is a form of central plant made semi-portable.

DRIVING A TUNNEL UNDER AIR PRESSURE AND FILLING IT SOLID WITH CONCRETE.

In order to stop a heavy leak which threatened the ultimate undermining and destruction of Lock No. 3 on the Cayuga and Seneca Canal at Seneca Falls, N. Y., a tunnel was driven under compressed air beneath the walls of the lock, the leak located in a bad stratum of rock and effectively checked with a concrete cutoff wall. The small size of this tunnel, 4x6 ft. net section, required special equipment for handling muck and concrete. On account of the large volume of the leak a heavy battery of boilers and compressor equipment had to be ready for emergency service at all times.

The methods employed permitted the completion of the job without interfering with the water level in the canal.

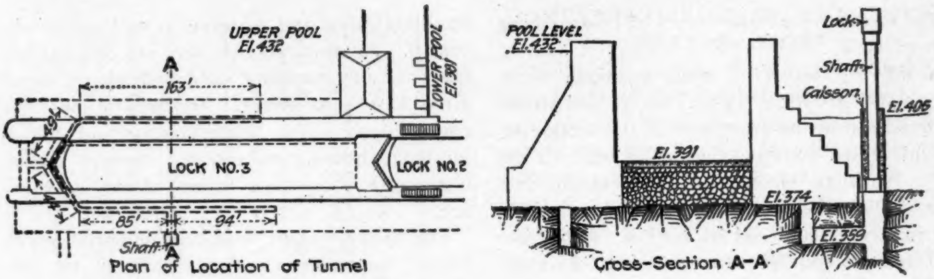
The Cayuga and Seneca Canal is a branch feeder of the New York State Barge Canal It connects the northerly ends of Canandaigua Lake, Seneca Lake and Cayuga Lake, and empties into the Barge Canal at Montezuma, N. Y. At Seneca Falls, between Seneca Lake and Cayuga Lake, is a dam with a power house and twin locks, Nos. 2 and 3. These twin locks have a combined lift of 51 feet from El. 381 to El. 432 above mean sea level. Lock No. 3, which is the upper of the two, has a lift of 39 feet.

Shortly after completion of the locks and filling of the upper pool, a leak showed itself when the water was lowered in the chamber of lock No. 3. The leakage increased until it became too great to be carried by the weep holes in a two-foot concrete bottom which had been laid in the lock chamber to prevent scouring. This bottom would not resist the pressure of the head of water which it had to stand when the lock was empty, and was forced upward in several places.

Early in the spring of 1917 it was estimated that the leak amounted to about 70 cu. ft. per second, and seemed to be increasing. It was decided by state engineers that it was necessary to repair the leak to prevent undermining and destruction of the locks. It then became a problem to determine the general locality of the leak. The flow of water showed in several places in the lock chamber, but as these places were the points where the floor had been upheaved they determined nothing. There was also a leakage out through the ground behind the land wall of lock, the ground level there being about 26 feet below the level of the upper pool. This led the engineers to think that the leak was through some particular stratum of rock below the bottoms of the lock walls. The walls from one end to the other were not founded on the same stratum of rock. Profiles of the rock showed that the concrete had been placed on a surface at about El. 374 for about half the length of the walls from the upper ends and on a surface at about El. 362 for the lower ends of walls, there being an abrupt drop from El. 374 to 362. In making this drop several strata of rock had been crossed, one of which the engineers knew to be of poor quality. It then seemed the most plausible assumption that the leak would be found in this stratum of poor quality rock and at the drop in the bottoms of the concrete walls.

Methods of grouting were considered, but discarded for something more definite. It was decided to drive a tunnel under compressed air beneath the walls of the lock at about the elevation of this stratum of rock of poor quality. By this method it was thought the leak would be located, and if the tunnel was then filled with concrete would provide a cutoff wall under the main walls of the lock.

A reinforced-concrete caisson 8 ft. 4 in. x 9 ft. 4 in. containing horseshoe shaped collapsible steel shafting was built up and sunk behind the land wall of the lock as near the upper end as practicable. This caisson was sunk from the ground elevation behind the wall, which was 406, to rock at El. 372. A hole 8 ft. square was excavated in the rock down to El. 353. When sunk, the top of the caisson was about 5 ft. above the ground.



PLAN AND SECTION OF TUNNEL UNDER LOCK WALLS

The steel shafting was raised to hold the air lock above the elevation of the upper pool. This made a shaft 89 ft. in depth from top door of air lock to bootom of pit excavated in the rock. From this shaft an entrance tunnel, 8 ft. wide and 6 ft. high, with bottom at El. 359, was driven a distance of 26 ft. toward the lock chamber. This distance reached a point beneath the center of the south wall of lock.

The main tunnel was then driven both east and west from the end of this entrance tunnel. The east branch was driven 94 ft. until it reached the step in the base of the concrete lock wall. The west branch was driven 85 ft. to a point opposite the intersection of the upper breast wall with the south lock wall. An angle of 60 degrees, a course of 45 ft., an angle of 60 degrees and a course of 49 ft., and another angle of 60 degrees carried the tunnel around under the upper breast wall and started down the north wall of lock. The tunnel was then driven 163 ft. to the step in the base of concrete of north wall.

Specifications called for a tunnel 4 ft. wide and 6 ft. high, but it was difficult to blast rock in so small a hole and it broke more nearly 5 ft. wide and 7 ft. high. During the driving of the tunnel some pockets of poor material and some small leaks were encountered, but nothing to make so great a leak as was indicated by the disturbance of the water in the lock chamber.

The roof of the tunnel being at El. 366, there was about 8 ft. of rock between it and the bottom of the concrete walls, 374 being the mean elevation of the bottom. A series of test holes 8 ft. apart were drilled in this rock overhead. They indicated readily that the leak was passing through a porous seam of material just underlying the concrete walls. Pipes were fitted in these test holes and grout was forced into them under pressure until they refused to take more.

The test holes showed that the main leak was located directly under the walls at the intersection of the upper miter sill and the outside or north wall of lock. A little different procedure was used in the case of this main leak to insure only proper results. The lock chamber was filled, thus equalizing the pressure on both sides of the wall under which the leak was located. This stopped any flow of water through the channel of the leak. About 300 bbl. of cement were required to grout the holes which led into this channel. After grouting, the pressure on the north wall was kept equalized for five days. At the end of this time when the water was lowered there was no evidence of any leak, showing that the grout had done its work.

The next step was to remove the rock overhead and extend the top of the tunnel to the base of the original concrete walls and fill the tunnel with concrete, making a cutoff wall. Beginning at the farthest end of the tunnel, a section about 30 ft. long of the rock overhead was taken down and the space filled with concrete to make a cutoff wall. Beginning at the farthest end of the tunnel, a section about 30 ft. long of the rock overhead was taken down and the space filled with concrete. In placing concrete the old benching method was used.

After the first section had been filled a different method was adopted for taking down the overhead rock and filling with concrete. There was about 8 ft. of rock to come down. On account of the narrow width of tunnel, this was too much to be taken down with one round of drilling and blasting. Four feet of it was taken down and a 6-ft. bench of concrete placed. This made a platform from

which to work to take down the remaining 4 ft. of rock.

In the top bench of concrete, pipes were placed for grouting. Pipe No. 1 led from the bulkhead at the front end of the section to a point at the roof near the back end. Pipe No. 2, with an elbow and short nipple, led from the bulkhead to a pothole shot in the roof near the front end of section. After the top bench of concrete was placed as close up to the roof of the tunnel as was practicable and allowed to set for 24 hr., the grouting machine was hooked up to pipe No. 1, and grout was forced through this pipe until it filled the joint between the old and new concrete, rose up in the pothole, and was forced out the vent pipe No. 2. This insured a tight joint on the top of the cutoff wall. This method of taking down the rock overhead, filling with concrete and grouting the joint in sections was followed until the tunnel was filled.

When the rock was taken down at the intersection of the upper miter sill and the north wall, the cross sectional area of what had been the channel of the main leak and had been filled with grout was clearly shown. It was an area shaped like the segment of a large circle with a chord length of 11 ft. and middle ordinate of 27 in. The grout which filled the opening was solid and free of anything foreign, showing that the leak had a clear channel of 12 sq. ft. cross-sectional area.

Both for excavation and concreting the material was handled in dump cars specially built for this tunnel. Trucks of 24-in. gage flat cars were surmounted by wooden bodies of ½ cu. yd. capacity hinged under the middle for dumping. There was a 24-in. gage track laid the full length of the tunnel with a turntable at the intersection of the entrance tunnel with the main tunnel under the south wall. The bottom of the shaft being 6 ft. lower than the bottom of tunnel permitted dumping the cars of muck directly into the caisson bucket handled by a derrick at top of shaft. When concreting, an inclined platform was set up in the shaft about 5 ft. above the bottom of tunnel. Concrete was dumped from the bucket, handled by derrick on the platform, and thence moved by gravity into the car.

The contracting firm was well equipped with plant for this piece of work. There being but one shaft, only one derrick was required for handling labor and material in and out of the tunnel. Another derrick was set for unloading coal and handling sand and gravel direct from barges to mixer. Temporary buildings consisted of boiler house, compressor house, sandhog house, storeroom, cement house, blacksmith shop, pipe fitters' shanty and office.

The power plant was uncommonly good. Three locomotive boilers totalling 300 hp. were set up in battery and one 80-hp. boiler laid outside in case it should be needed. Three large low-pressure air compressors and one medium size high-pressure machine were set and ready for action on short notice. One of these low-pressure machines furnished air for the tunnel during almost the entire job. Occasionally a leak was encountered that required two compressors for short periods.

The box for the shaft caisson was ditched about 8 ft. in the open before the air lock was placed. Air was turned on Aug. 2, 1917. The shaft was built up and sunk 26 ft. through broken shale and 19 ft. through rock, a tunnel 6 ft. x 8 ft. was driven 26 ft. The main tunnel, 5 ft. wide with average height of 14 ft., was driven 436 ft. in shape of a horseshoe. Leaks were grouted and stopped, tunnels were filled with concrete, and air was taken off Dec. 18, 1917. Eight days of this time was chargeable to work on an additional spur tunnel not included in the original contract. Counting out these eight days, air should have been taken off Dec. 10, 1917.

The work was done by the Foundation Company, under the direction of W. B. Taylor, district manager for the company in that territory. The writer was superintendent in charge of the work. The State of New York was represented by H. C. Smith as resident engineer and C. H. Swick and L. W. Bently as inspectors on the work.—*Engineering News-Record.*

HOW PNEUMATIC TIE TAMPING PAYS

The United Railroads of San Francisco rerecently tried out and adopted a pneumatic tie-tamping outfit which has been found to afford a saving in cost and labor. As careful records were kept of items entering into both hand and pneumatic tamping methods it has been possible to compare the two methods in detail.

The equipment used is an 8-in. by 6-in. In-

TABLE I—COSTS WITH HAND TAMPING

Labor	$0.257 per foot of single track
Tools, superintendence and overhead	0.017 per foot of single track
Total	$0.274 per foot of single track
Or $1,446.70 per mile.	

TABLE II—COSTS WITH PNEUMATIC TAMPING

Labor, including moving	$0.117 per foot of single track
Current	0.011 per foot of single track
Maintenance, oils, superintendence and overhead	0.010 per foot of single track
Depreciation and interest	0.006 per foot of single track
Total	$0.144 per foot of single track
Or $760.30 per mile.	

gersoll-Rand ER-1 compressor which has a piston displacement of 94 cu. ft. per minute. This compressor, sufficient for the operation of four tools, is driven by a 20-hp. motor operated by connection between trolley and rail.

An average of seven jobs in which 2692 ft. of single track was ballasted with hand tamping gave the figures as to this cost given in Table I.

Based on the same wage conditions and on the same track, namely 6-in. by 8-in. ties, 8 ft. long on 2-ft. centers, the costs shown in Table II were found typical for pneumatic tamping. These figures being based on a crew of seven men and four tampers making 180 ft. of single track per day.

Thus the saving effected by the pneumatic equipment amounts to about $686.40 per mile of single track. It is believed that a more compact roadbed can be secured by this method. Moreover, the fact that labor required is more than cut in half is considered a strong point in favor of the pneumatic method in times when the labor problem is acute.

The work on the United Railroad properties is under the direction of B. P. Legare, chief engineer of maintenance of way and construction.—*Electric Railway Journal.*

COMPRESSED AIR IN THE FURNITURE FACTORY

During the last few years, since wages have been going up and finishers have been becoming scarcer, most up-to-date factories have put in sprayers in the finishing room, also rubbing machines which are run by compressed air. Now, when a firm goes to the expense of putting in an air compressor and tank, the outfit may as well be made to do more than simply supply the finishing room. In our factory we have put it to use in the machine shop as well.

We run a ¼-in. pipeline from the compressor to our band saw, and use it as a blower for brazing saws. It gives so much stronger flame than the ordinary blower that we also use it for tempering all shaper knives. We also have a pipeline to our three-drum sander and a 30-ft. hose attached to it, which we use for blowing the dust off the machine. Formerly it took a man from ¼ to ½-hr. to clean up the sander with a duster; now he can do it easily in five minutes and do it much better, as it cleans out all the corners. The hose connection to the pipe is just in front of a window, so we use the same hose outside, to inflate the tires of our autos.—*The Woodworker.*

TORCRETE

"Torcrete" is a reinforced concrete specially prepared for ship construction and is said to bear about the same relation to ordinary concrete as rolled steel does to cast iron. Instead of being poured in forms the materials are shot in place by means of compressed air with the "tector," a new type of concrete blower. The processes are the invention of a Mr. Weber. The preparation is discharged on layers of steel fabric or wire mesh, and there may be as many layers as is necessary to produce the required thickness, the layers themselves massing with one another so as to form a perfect solid. It is claimed the torcrete vessels are lighter than wooden ships, built in shorter time and at lower cost than any other type of concrete ships, and that the method of construction is adapted to any size of craft or any form of metal that may be desired. A vessel of 3200 tons displacement has been contracted for by the Southern Oil and Transportation Company.—Philadelphia *Public Ledger.*

THE ARGUMENT FOR THE ONE-MAN DRILL

By J. Parke Channing*

About ten years ago I started to develop a low-grade copper mine in Arizona. As mine superintendent I had N. Oliver Lawton, a member of this Institute, whose experience at Lake Superior has made him familiar with what is known as the one-man air-drill. This is a light machine weighing about 125 lb., which can be readily set up and operated by one man. We started to use these in Arizona where, before, nothing but the larger and heavier machine, requiring two men, was in use. There was an immediate opposition from the men and we were accused of trying to throw half the normal number of miners out of work. Whenever I went through the mine I took the opportunity to tell the men that this orebody, up to that time, had not been considered 'ore,' that it was 'rock,' and that nobody thought it was worth exploiting; that far from throwing one man out of work, we were giving two men jobs, that if two men had to work on a drill the cost of mining would be so high that the material would not be ore, but that if we gave each man a drill and put him to work in a separate drift, then the rock would become ore, that these men would have employment and that a new industry would be started. About three months of this propaganda convinced the men of the truth of our claim, and in a short time it would have been impossible to get the men to go back to the old two-man drill because each man now felt that he stood on his own feet and got credit for the whole distance he drifted. This is only one example, but it indicates what can be done by education. The old-time manager or old-time superintendent would simply have said, take the job or leave it; but this is not the attitude for the modern engineer.

COMPRESSED AIR IN ELECTRIC STATIONS

Compressed air is frequently employed for blowing out switchboards, and the apparatus mounted upon them. For the rear of the board a pressure between 50 and 80 pounds per square inch suffices for removing dust from conductors, oil switches, rheostats, and so forth. The nozzle of the hose should be insulated, of course, so that there is no possibility of causing short-circuits or shock to the operator. Compressed air may also be used for the front of the board, for blowing round meters, switches, etc. However, for the front it is often considered better to use a bellows rather than high-pressure air. With a bellows it is permissible to remove the glass covers of relays and meter covers and blow gently, thus removing dust that insists on settling. The valves of overload bellows-type relays may also be cleaned in this way, at which time it is good practice to determine the workability of the relay. High-pressure air should not be used for these purposes, as meters would be damaged and there is also likelihood of dirt being blown into the valves of relays, obstructing them, and making them unworkable. In a station there is a place for both high and low pressure air, and each should be used only in its place.—*Electrical Review.*

*From address at meeting of Boston section. American Institute of Mining Engineers.

PNEUMATIC DOOR CONTROL

With the advent of women in ever-increasing numbers as conductors on electric cars, devices that contribute to ease of operation of cars are finding a wider market and readier sale. An illustration of this is furnished by air door engines, as they are described by one manufacturer; and pneumatic door and step control by another. The engines or controls save in energy consumption, because stops are shortened through faster opening and closing of doors. Where women are employed on one-man cars the closing or opening of heavy car doors and the dropping or raising of weighty steps by mechanical means is being seriously considered. Because one important Eastern road had placed 250 pneumatic engines on its subway cars, the employment of women guards has proved easy. The same company also has 100 surface cars so equipped and operated largely by women conductors. Simply by touching a push button the door engine, which can be adjusted for any speed of travel desired, is operated without the slightest physical effort. As further proof of their utility and popularity, these door controls or engines are being introduced on the leading traction systems all over the country.—*Electric Railway Journal.*

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FOR FAIR PLAY FOR THE MAIL TUBES

Possibly it has never been suggested that Nero fiddled while Rome was burning because he could fiddle better then than under any other conditions. In these desperate times when catastrophies are occurring with which the burning of Rome is not to be compared, trivialities are indulged in which delay the consideration of the serious matters that confront us.

The pneumatic tubes in the post offices of the large cities have undoubtedly made good, have demonstrated their practical value by years of service. They should not be kept in a state of siege and it should not be necessary to continually watch and defend them. The following, from the *Congressional Record,* is presented in defence of the tubes, as economical and efficient accelerators of business, by Representative Steenerson of the Joint Congressional Tube Commission:

We went to work as best we could and spent weeks in examining into these matters, and held hearings in all these cities, and visited them all. Of course we supposed that when the dispute between the Department and these cities about this service was referred to the Tube Commission, which was created by law—a law signed by the President—that that should have some sort of effect to show that the Tube Commission was a sort of tribunal authorized to settle the dispute between the Department and the people who ordered the service and we went to work in good faith to make a report as to the quality of the service, whether it expedited the mail, whether it was safe and whether it was worth the money. And while we were considering that question the Department—while the question was pending before the Tube Commission—issued its annual report, in which it condemned the whole service and said it was not worth anything and that it should be discarded, thereby contradicting the report of the year before, where, basing their statement on the reports of their own experts, they recommended that the tube service should be continued in New York from Forty-second street down, a distance of more than thirteen miles, and basing their action upon the recommendations of the same men who made that expert report, came before the Post Office Committee of the House and asked for an appropriation to continue the New York tube service.

Now, if, as they have lately claimed, the tube service is unsafe, if it damages the mail, if it does not expedite the mail, if it is not efficient, why in the world did these same experts that are held up to us as the only men who know anything about the business recommend the continuance of the tube service in New York city?

There is an area in that congested city that is more crowded than any other city in the world. Take Fifth avenue, they say, from Forty-second street. Mr. Myers, the chief of traffic police, says from Fifty-fifth street down, or on Broadway, there are more foot passengers and more vehicles passing than in any other place in the world. Even in the city of London, around Trafalgar Square, or the Strand, or Pall Mall, or Piccadilly, or anywhere you cannot find any such crowded condition as you find in this congested district in the city of New York.

A year and a half ago these experts recommended that the tube service be continued there. But now they come around and say that the tube service is not worth anything, that it is junk, that it is no good, and should be abandoned everywhere. They wanted to put in a service that is unsafe, slow, unreliable, in the most thickly populated section in the world. They have criticised the Tube Commission for not paying sufficient heed to postal experts. This subject is city transportation. It is a subject that must be learned from actual experience and observation. Mr. Koons, Mr. Gardner, Mr. Johnston and Mr. Mullen were post office inspectors. It has been their duty to ferret out crime. They were detectives. Their work in no way qualified them as experts in this matter. The only man who had had any experience in city transportation was Mr. Ryan, who for a short time had been superintendent of mails in Philadelphia. Mr. Gardner, however, would not sign the report—refused to sign it—disagreed with the rest. These other three inspectors have claimed that they knew all about the subject, and that nobody else knew anything about it, and they have asked Congress to take on faith what they say about it. Evidently some people do. But the criticism that has been made upon the Tube Commission—that they did not consider the statements of the Department—is unfounded. The commission had before it the testimony of these experts before the House Committee and the Senate Committee.

Over in the House Committee the learned lawyer from Boston, Mr. Whipple, cross-examined the experts, and they did not come out so very well. Senator Bailey examined them. The secretary of the tube commission invited the department to submit their statements in writing, which they did, and those statements were printed in the report. All they had to say was printed without cross-examination. The object of cross-examination is to weaken the evidence of the witness. Yet they complain because we did not weaken the evidence of their experts by cross-examining them! We are glad to have omitted to call postal experts. How can you get postal experts outside of the Post Office Department? You must either take men who have been discharged or who have left the service. But there are business men who know a good deal about postal matters. The commission went to New York and they heard forty or fifty of the leading business men and representatives of business organizations, and, fortunately, we were able to get the man who, in my opinion, is the ablest postal expert on this subject that there is in the United States—Mr. Follmer. Mr. Follmer started in as an errand boy in the Postal Service, served 30 years, and advanced to be superintendent of delivery in the great city of New York. He had charge of the tube service and when the department last year proposed to change the tube service and to institute a Government-owned automobile service he was the man in the New York post office who was selected to lay out the schedules and the lines to operate the new automobile service. That shows that he was recognized by the department to be the most skilled man they had, so far as New York was concerned, and he did lay out those schedules and those routes. About six or eight months ago he was offered a position with the Bankers Trust Company to look after their mail. The Bankers Trust Company, one of the biggest financial institutions in the country, have very important financial mail to take care of, and they employed Mr. Follmer, so that at the time he was called before the commission he was not connected with the Postal Service and was free to give his opinion. I will insert his testimony in the *Record*.

We also had before us the testimony of ex-

Postmaster Morgan of New York, given before the House Committee at the hearing a year ago. I will insert that also in the *Record*. He strongly favored the continuance of the tube service. He was a real expert.

This testimony answers every objection that has been made by these claimed experts, who simply know by observation or information; but this is the testimony of a man who knew by actual experience, who had charge of the tube service. He says there is less in the way of accidents, less damage to the mail and greater expedition of the mail by the tube than by automobile, and it expedites the mail. That is a valuable thing in a large city like this, where $600,000,000 goes through the Clearing House every day, and 90 per cent. of that goes through the mails. If you send a check for $1,000,000 to a bank in New York, the customer is credited with, and it draws interest from the time the mail is delivered and the envelope opened and the check placed to his credit. . . . If you buy a large quantity of grain and pay for it with a check, if it takes longer to do that business, the expense of transacting the business is charged up in interest and the consumer has to pay it. That is the reason why every business man in New York and every other city says that if you delay the first class mail you touch the very nerves of business life. If you delay the financial transactions of this country, you delay the consummation of trade, and thereby increase the cost of living a great many times more than the whole postal service costs.

Mining methods in New York City—in new subways—vary considerably. In the sand and gravel strata, close timbering is necessary, with half sets. In hard-pan—gravel and clayey matter—a shield is used, this being pushed ahead as excavation proceeds. In rock—a schistgneiss—ordinary drilling and blasting methods are in vogue. Mining in the city is of far greater extent than generally thought and by the end of 1918 there will be 308 miles of subways. This does not involve the excavating of a small tunnel, but one the full width of a street and often wider. At the same time traffic on the surface must not be interfered with by the underground work. Eventually there will be 600 miles of underground lines, costing $400,000,000 in all—"and then some."

NEW BOOK

Mining Engineers Handbook written by a staff of Specialists under the Editorship of Robert Peele. New York, John Wiley & Sons, 2385 pages, 4¼ by 7 in., 3 in. thick, flexible covers, full gilt edges, crowded with pertinent cuts. $5.00 net.

Professor Peele's earlier book, "Compressed Air Plant," showed him to be careful and thorough, and the present work confirms the estimate. Five years ago, he says, the editor outlined the table of contents and invited a number of associate editors to contribute sections on their respective specialties. There are in the book 43 sections with the name of the responsible editor of each. There are, by the way, more than 8,000 items in the index. The book is not only compact with actual, usable information without theorizing, but also tells where to seek for more along the same lines. Notwithstanding the bulk of the work the matter contained is all immediately pertinent to the general subject of mines and mining presented in the most compact form. The only possible suggestion of padding in the book is about 30 pages of the tables which are in all the pocketbooks. It is not out of place to call attention to the low price of this bulky but beautifully printed book.

AN UNUSUAL AND FATAL COMPRESSOR ACCIDENT

A serious accident occurred at the storage warehouse of the Merchants Refrigerating Company, 16th and 17th Sts. and 10th Ave., New York City, May 18. At 7 P. M., according to the account in *Refrigerating World*, "a piston rod pulled out of one of the ammonia compressors while running at high speed and thrashed about, partially wrecking the machine." This, we confess, is to us entirely unintelligible. We would rather suggest that it was the connecting rod accidentally disconnected at the crosshead, which did the thrashing.

The remainder of the account is perfectly intelligible. "Relieved of its load the flywheel burst under the increased speed and the engineer was killed. Ammonia gas escaping from the compressor filled the machinery department. Emergency calls brought the fire department with gas helmets and pulmotors and the fire engines.

"A system of flushing the ammonia system

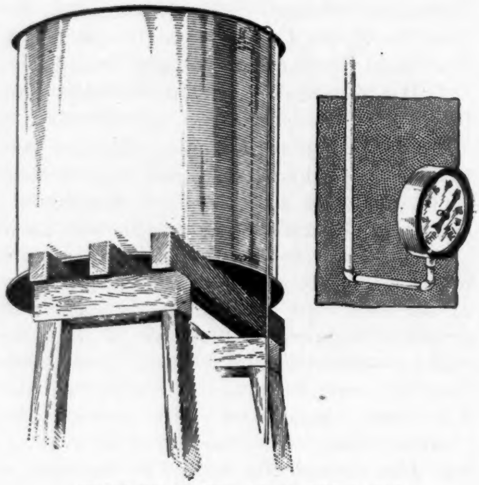
into the sewer with water had at once been put into use after the accident and a vastly greater calamity was thus avoided, but the machinery department had been filled with explosive vapor mixtures. As there was no inflammable material in the basement we understand that the engineers present protested with the fire department against turning water into the premises but that was unavailing, the fire officials urging that the water would absorb the fumes. When the water was turned in, or very soon thereafter, a violent explosion occurred, believed to be due to the effect of the water in short-circuiting the electrical mains from which the plant was operated. The machinery was run entirely by electric current.

"Many firemen and soldiers guarding the barred zone, and others on the outside of the building were hurt by the fumes and the effects of the explosion, among them the company's chief engineer Wm. E. Berend. Owing to the late hour only the night crew was employed in the building, most of whom were out of the way of the explosion, the force of which, going up through the shaft carrying the brine pipes to the refrigerating rooms in sections above, blew many of the doors from their fastenings or wrenched them loose, or blew them open, and filled the rooms with smoke and fumes. Apart from the blowing out of these doors the damage to the house itself was insignificant, but refrigeration was shut off from the entire plant and the damage to goods stored was considerable."

A PNEUMATIC WATER LEVEL INDICATOR

An ingenious correspondent has sent to one of our most esteemed exchanges the sketch here reproduced—a photo would have been so much more convincing—with accompanying description as follows:

"A convenient water-level indicator for a remote water tank can be made as shown in the accompanying illustration. A 4-in. pipe is vertically installed in the tank, on top of which is screwed a 4 x 1/8-in. reducer, the bottom end of the pipe being left open and supported about an inch from the bottom of the tank. A line of 1/8-in. pipe is run to a convenient point and an old pressure gage attached to it. As the tank fills it is evident that the air entrapped in the 4-in. pipe cannot escape, hence it must undergo compression. As



PROPOSED WATER LEVEL INDICATOR

the amount of this compression depends on the height of the water level in the tank, the gage reading will thus increase as the water rises in the tank. A dial was placed on the old gage, and by experiment various heights in the tank are marked upon it as determined by trial. Where the tank is far from the gage, it is better to incline the big pipe in the tank, so that a greater volume of air is entrapped, thus making up for any drop in the small pipeline. Of course, it is a good plan to go up in the tank once a season and check up on the gage."

It should of course be unnecessary to remark that all the piping and connections should be absolutely and everlastingly leakless, and that the temperature of the enclosed air, and consequently that of the water in the tank, should never change. We are not told where a pressure gage with a range sufficiently minute could be obtained. Say that the total range of water level in the tank was 10 feet between highest and lowest, then the maximum difference of air pressure would be 4 1/3 pounds. As the water rose or fell in the tank there would also be a change of level of the water in the pipe, and this would affect the indications.

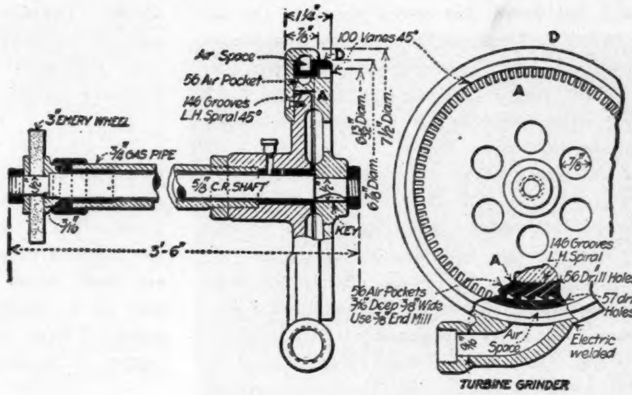
AIR - TURBINE - DRIVEN GRINDING WHEEL

By W. J. Nene

One of the most pronounced difficulties associated with the electric welding of cast iron in the small shop is the tendency to leave the

weld so hard as to be practically unworkable by any form of tool short of an abrasive wheel.

This is especially true when joining small parts to a larger body, where the mass of metal adjacent to the weld is sufficiently large to conduct the heat rapidly from the welding point; and with the usual perversity of inanimate things these hard spots are generally located at places most inaccessible to the ordinary form of grinding apparatus.



AIR DRIVEN GRINDING WHEEL

While this trouble may be minimized by the introduction of silicon by means of the welding rod or directly into the weld it has never been wholly eliminated, and to give the operator a quick and efficient means of working down these hard spots the grinding machine illustrated herewith has been devised.

This machine is simply an air turbine of special design, carrying an abrasive wheel on the end of its rotor shaft and combining simplicity of construction with lightness and ease of manipulation.

I do not claim originality in the application of the air turbine to the hand-grinding machine, but merely submit the following description and vouch for the machine's efficiency. The turbine furnishes ample power at 90 to 100 lb. pressure to drive a 3-in. wheel at 6500 r.p.m., which is approximately correct for a wheel of this size.

The machine as used for grinding welds is usually held in the operator's hands, and being well balanced there is practically no vibration except it be caused by wear of the grinding wheel during the actual grinding operation. It has also been used for internal, external and center grinding, being held in the toolpost of a lathe, and as a hand-polishing wheel for certain parts of locomotive side rods, etc.

All parts are made of mild-steel forgings except the ring *D* and the bearings, which are of hard brass, and the ball races, which are of tool steel hardened and ground. The air connection, or intake, was electrically welded in position after the other parts were machined.

The compressed air enters the annular chamber marked "air space" on the cut; thence flowing through the air ports (that is, the fifty-seven 3/64-in. drilled holes) and impinging at high velocity on the air pockets in the rotor *A*, imparting to it the first rotary impulse. At this point the air divides, part flowing through the 1/16-in. holes in the rotor and thence toward the center, where it exhausts through the six ⅞-in. holes, while a larger portion of the air flows through the 1/64-in. opening between *A* and *D*, where it comes in contact with the vanes or wings which form part of the rotor and are set at an angle of 45 deg. with the axis of the rotor.

As the combined area of the 57 air ports is approximately 0.098 sq. in., a ⅜-in. air hose would furnish an ample supply of air, but the usual standard connection for small hose is ½-in., and for this reason the air intake of this machine is made of this size.

A feature of this turbine is that when running at full speed it seems to use very little air; in fact it is necessary to hold the hand quite close to the machine in order to feel the exhaust.—*American Machinist.*

ELABORATE AND COSTLY AIRPLANE EQUIPMENT

The following is abstracted from publications of U. S. Signal Corps:

Before an airplane can be put into military service it must be equipped with nine or more delicate aeronautic instruments, some of which are absolutely essential to exact flying, and all of which contribute to successful operation. Without them a pilot would soon lose his location as to height and direction; he

would not know his speed through the air, the speed of his propeller, the amount of gasoline in his tank, the temperature of his cooling water, or if his oil was circulating. He could not tell whether he was banking properly on his turns.

These comprise the necessary flying instruments, but an aviator could not fly to any great height without another valuable instrument, an oxygen supplying apparatus, nor could he operate his guns, signal headquarters, release his bombs, or "shoot" his cameras without additional mechanisms.

All these instruments must be ready for installation as soon as the airplanes are assembled, for no plane is complete without them. In some instances, as for the two-seaters and the heavy bombing machines, two and even three of each sort are necessary, totaling sometimes as many as 23, but for ordinary work only about 9 are needed. The average cost of a set of navigation instruments for a single plane is $350.

For the operating of actual observing, photographing, bombing and fighting planes many other complicated and expensive instruments and sets of apparatus are necessary. Among them are machine guns, gun mounts, synchronizers, bomb racks, bomb dropping devices, bomb sights, radio, photographic and oxygen apparatus, electrically heated clothing, lights and flares. The cost of these additional accessories would bring the total cost of equipment up to several thousand dollars.

Various instruments have been developed or improved by the Signal Corps, including:

THE TACHOMETER

This instrument indicates the number of revolutions per minute at which the engine is running. Unlike the speedometer on an automobile, it does not translate revolutions into miles per hour; another instrument gives the speed in relation to the air. When instrument matters were taken up last July there were no tachometers manufactured in this country of the type which has proven most successful abroad; namely, the escapement or chromatic type.

THE AIR SPEED INDICATOR

This is a pressure gage for showing the speed of the plane in relation to the air, not the earth. This instrument includes what is known as a Venturi-Pitot tube, which is fastened to a strut and takes in the air from ahead. The air sets up a corresponding pressure in an auxiliary tube, which is calibrated and indicated on a dashboard recording pressure gauge.

THE ALTIMETER

The altimeter is an aneroid barometer, graduated to read height above the earth instead of pressure. Under standard specifications a reduction in weight and size was effected in the manufacture of these instruments, which are now being produced in large quantities and of a quality equal to the best foreign make. Three standard types are made with ranges of 20,000, 25,000 and 30,000 feet.

THE AIRPLANE COMPASS

After much experimental work this instrument has not yet reached the perfection desired. A new type, having advantages over any present form of compass, especially as to compactness, is now used. In the development of this instrument effort has been made to reduce the weight to the safest possible minimum and to decrease the space required in the airplane.

AIRPLANE CLOCKS

Due to the development which had been made in clocks for automobiles, it was only necessary to standardize a design of mounting in order to adopt such clocks to airplanes. Sufficient quantities are now available for all needs.

PRESSURE GAGES

Instrument-board pressure gages were already manufactured here in large quantities, and as soon as standard specifications were developed production started. Two types are used, one to register the air pressure which forces the gasoline to the engine and the other to show the pressure produced in the oiling system by the oil-circulating pump. Standard forms of cases and dials with interchangeable glasses and bezels have been designed.

THE RADIATOR THERMOMETER

This instrument is mounted on the instrument board, where it indicates the temperature of the cooling water in the engine. Undue heating shows that the engine is not running properly or that more water is needed. Thermometers of this type made here were, and still are, being submitted to extensive tests.

BANKING INDICATOR

This is an instrument used to show when a plane is correctly banked in making a turn.

Spirit level, balance, and gyroscopic types are being used. The problem of indicating the extent to which a plane is inclined to the horizontal in the air is a very complicated one. No simple solution has yet been reached. Fortunately, it is not often necessary to determine whether the plane is exactly horizontal, except in connection with bomb dropping. Development work is under way which it is hoped will lead to improvement of devices already in use abroad.

THE ALDIS SIGHT

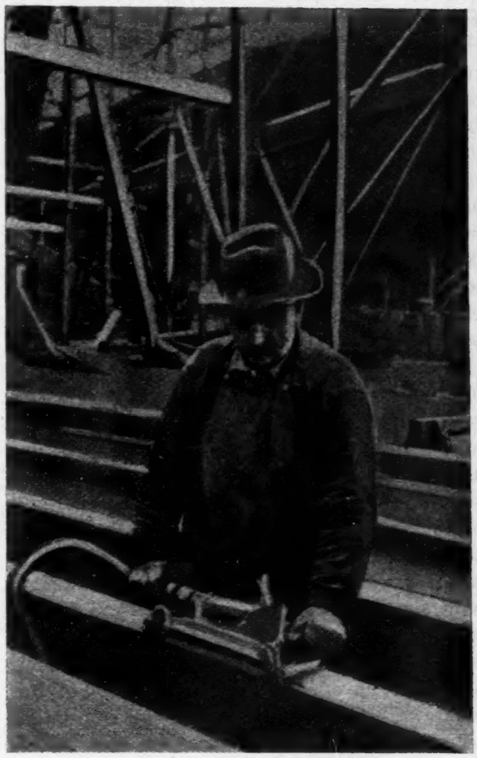
This sight, which is used in connection with fixed guns firing through the propeller, has been copied, as regards its optical features, from an English instrument; but the construction has been modified in such a way that the behavior of the instrument in actual use will probably be very much improved. After a number of tests and experiments satisfactory instruments are now available. The makers have been assisted in recomputing the lenses to suit the optical glass available in this country. The illumination of these sights for night operation is also being studied.

FACTOR OF UNSAFETY

On a recent trip to a remote part of the state of California, one of the boiler inspectors of the Industrial Accident Commission found an installation which was, to say the least, unique. The boiler was of the vertical tubular type, 30 in. in diameter, and was fitted with a ball-and-lever safety valve. In addition to the ball weight, the lever carried four large-sized horseshoes. Upon inquiry it developed that the operator of the boiler thought he had a factor of safety of 5, since he carried only 40 lb. pressure, and the steam gage was graduated to 200 lb. Any idea that the horseshoes were a symbol of good luck, was soon dispelled by the inspector, who pointed out the grave danger of "loading" the safety valve.

PORTABLE PNEUMATIC WOOD PLANER

The tool here shown in operation is one of a line of air planing machines manufactured by the Shipbuilders Pneumatic Tool Company, Portland, Oregon. The ready adaptability of this tool, especially in ship building work, is evident at once. It can be applied to surfaces to be planed anywhere and manipulated with perfect ease while often difficult or impossible to bring the work to a stationary machine. These planers are rotary machines operated by air driven turbines which run at 8,000 to 15,000 turns per minute. There is only one movable part and the cutters are easily removed for sharpening and reset. The amount of cut at each pass-over is instantly adjustable. In a trial of one of these machines at the Foundation Company's Portland plant a workman planed 385 square feet in five hours, while eight men with hand planes finished 275 square feet in seven hours.



PNEUMATIC WOOD PLANER

FOG IN THE BOILER ROOM

By G. C. Derry

In a power plant at Port Henry, N. Y., on the shores of Lake Champlain, a troublesome vapor condition existed in cold weather from cold air coming in and condensing the moisture in the warm air in the boiler room, which caused a fog so dense that the firemen could scarcely see their steam gages and water

glasses from the floor of the boiler room. Several plans for getting rid of the vapor were tried without success. The coal supply was just outside the boiler room, and there was a continual opening and closing of doors as the firemen brought the coal in. The fog was so dense, in fact, that when the firemen started in with the coal, they had to shout in order to avoid running into each other, and it was difficult to get men to stay and work under such conditions. Water tenders had to be put on in order to watch the water gages from an elevated platform constructed in front of the boilers.

A condition existed which resembled the blowing of one's breath into cold air in the winter time, and it seemed to me that the logical thing to do was to bring the incoming air up to the temperature of the room or possibly a little higher, so it could carry off some of the vapor. Proceeding along these lines, a large heater and multivane fan were installed which drew the air from the room, mixed it with some fresh air from outside and forced it through a duct system leading along the sides of the room and down each side of each door and up against the cold surface of the windows. The fan and heater were installed on an inclosed platform over the door which led to the coal pile, and advantage was taken of this platform—making it a ceiling of a room into which to pour a large amount of heated air.

The fan had a capacity of 33,000 cu. ft. of air per minute, and the air in the room was changed every three minutes. The heater was capable of heating this amount of air from 10 deg. to 158 deg. when supplied with steam at 60 lb. pressure. The system had the advantage of removing the steam in the winter and also providing a means of ventilation in the summer.

The owner has advised us that the system worked satisfactorily, removing every trace of the vapor even during the extremely cold weather last winter.—*Power.*

NOTES

A Boston hotel with a large electrical sign, when compelled to cut off its illumination under the Fuel Administration order prohibiting such uses of current, had the sign painted with luminous paint, which is said to be fairly satisfactory war-time substitute.

Approximately Fifty million car stops are made in the United States each day. The "skip-stop" schedule would eliminate one-third of these. The elimination of six billion stops a year, together with the regulation of car heating, will bring a fuel saving of not less than 1,500,000 tons of coal a year, which will meet the fuel needs of 300,000 average families.

The air compressor has become a very important factor in the production end of the retail monument shop. The compression of air for use in penumatic tools, air polishing machines and sand blast machines not only reduces the production cost of a monument, but it gives to the retail dealer a prestige which stamps him, in a way, as an up-and-coming business man.—*Granite, Marble and Bronze.*

Compressed-air hoists, pumps, and drills are fast displacing steam-power in the Missouri-Kansas-Oklahoma zinc-lead region. As far as economy is concerned it has been demonstrated that with direct-connected gas-driven air-compressors the entire shaft-sinking equipment can be operated much more cheaply by air than with steam. The only reason why compressed air is not more favorably regarded and more generally employed is that proper precautions are not taken for draining the air and avoiding the freezing up of the exhausts.

Reinforced concrete for building walls is commonly mixed quite wet and is usually compacted by spading it. Concrete containing less water, and of a quaky rather than fluid consistence, is sometimes specified; but it cannot be tamped economically in thin reinforced walls. However, it can be compacted by striking the forms and the reinforcing bars with a light wooden maul. This suggests the possibility of using a pneumatic hammer for this purpose, for a large number of sharp light raps should be effective in causing the concrete to settle in the forms.

Cement and Sand—3 to 1 mixture—sprayed on mine timbers, by compressed air, renders them fire-resisting to a considerable degree. Any desired thickness may be built up by spraying in layers, by the cement gun.

Tearing up city streets in order to sell the paving material is being seriously considered by the city officials of Butte, Mont., according to advices from that city. A few years ago some of the streets were paved with manganese ore, which at that time was considered worthless. Since then the war has caused a heavy demand for manganese, and the manganese rock used for paving is now valuable.

According to authoritative figures the increase in the production of motor trucks during the first three months of 1918 amounted to 100 per cent. over the production a year ago. It is expected the total output of trucks for 1918 will represent a higher value than the output of passenger cars. The production is now on a basis of 310,000 trucks for this year at an average price of $2,000 or a total production figure of $620,000,000.

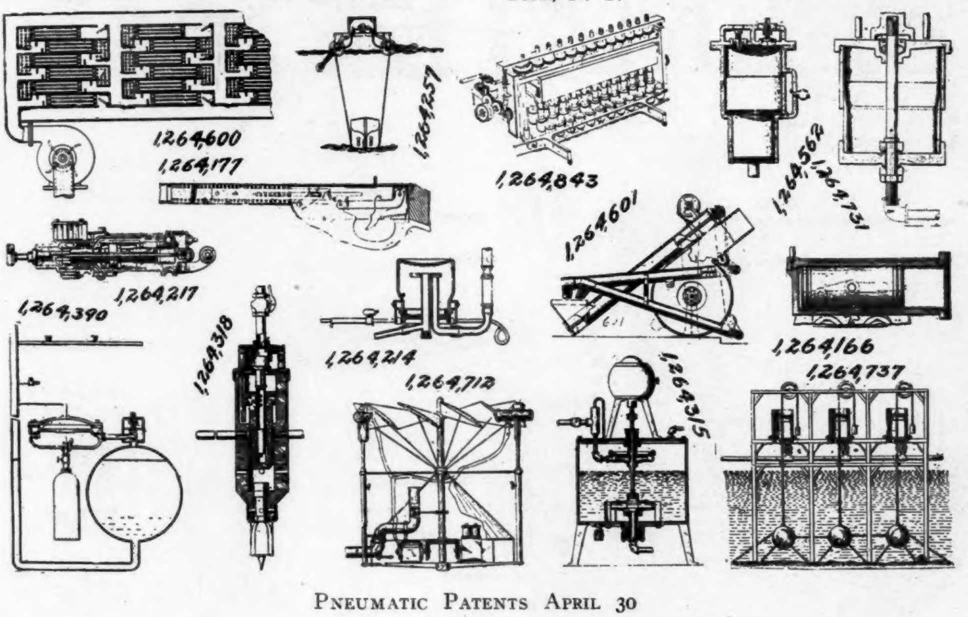
The first man-carrying airplane flights were made in December, 1903, with the Wright Brothers' engine, developing 12 hp. and weighing 12.7 lb. per. hp. In 1910, seven years later, the average horsepower of aeronautic engines had increased to 54 and the weight decreased to 5.7 lb. per hp. In March, 1918, the Liberty 12 developed 432 hp. for a weight of 1.86 lb. hp. By May, 1918, the Liberty 12 was yielding a maximum of 450 hp. for a weight of 1.83 lb. per hp. The Langley-Manley engine, built in 1901, was nine years ahead of its time in the matter of power output and 16 years ahead in its weight per hp., developing 52 hp. and weighing 2.9 lb. per hp.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

APRIL 30

1,264,166. AUTOMATIC CLOSING DEVICE FOR FIRE-DOORS. Albert G. Elvin, Somerville, N. J., and Frederick W. Martin, New York, N. Y.



PNEUMATIC PATENTS APRIL 30

1,264,177. AIR-GUN. William B. Greenleaf, Plymouth, Mich.

1,264,214. MILKING-MACHINE. Warren A. Shippert, Dixon, Ill.

1,264,217. ROCK-DRILL. William A. Smith, Denver, Colo.

1,264,257. APPARATUS FOR RAISING SUNKEN VESSELS. Walter C. Beckwith, Fostoria, Ohio.

3. In an apparatus for raising sunken vessels, a pair of pontoons, a framework carried by and connecting said pontoons, a deck upon the framework, windlasses supported by the pontoons, levers adapted by their rise and fall to actuate said windlasses, floats, carried by the levers, an air compressor connected with said floats, a conduit between the air-compressor and the floats, and means for the control of the ingress and egress of air and water to and from said floats.

1,264,315. COMBINED ASPIRATOR AND FORCE-PUMP. Edward F. McCarthy, Chicago, Ill.

1,264,318. PNEUMATIC TOOL. John T. McGrath, Bloomington, Ill.

1,264,390. AUTOMATIC FIRE-EXTINGUISHING APPARATUS. John R. Hamilton, Yonkers, N. Y.

1,264,562. FLUID-COMPRESSOR. Edward A. Rix, Oakland, Cal.

1,264,600. METHOD OF AND APPARATUS FOR DEHYDRATING FRUITS, VEGETABLES, AND SIMILAR ARTICLES. George Hillard Benjamin, New York, N. Y.

1,264,601. CONVEYER. George Bernert, Milwaukee, Wis.

1. In a pneumatic grain conveyer, a casing having a blower fan therein, a trunk extending from the casing, a conveyer drum communicating with the trunk, means for preventing the accumulation of grain in the fan casing, and means for returning grain dropped in the fan casing to the conveyer drum.

1,264,995. BLOWER. John C. Swaykus and Alex Tracz, Lackawanna, N. Y.

1,265,002. FLUID-PRESSURE BRAKE. Walter V. Turner, Wilkensburg, Pa.

1,265,014. COTTON-SEED LINTER. James T. West, Rockingham, N. C.

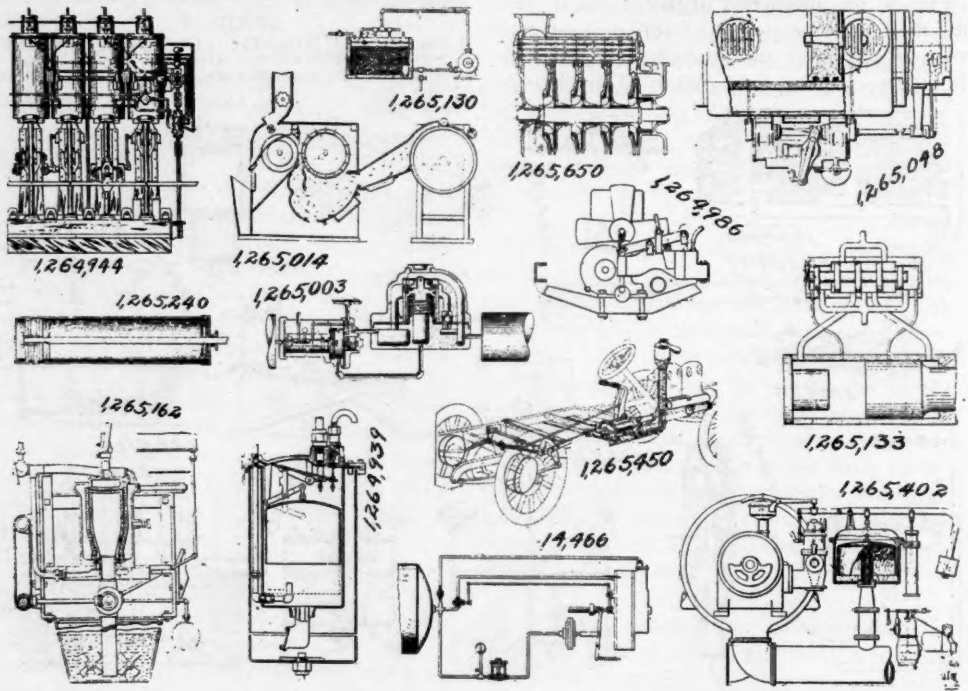
1,265,048. AIR-COMPRESSOR. Carl A. V. Carlsson, Washington, D. C.

1,265,130. PROCESS OF CURING OLIVES. Homer C. Staley, Hayward, Cal.

1. The process of curing olives which consists in subjecting the olives to a lye bath and subsequently subjecting the olives to a bath of continously artificially aerated circulating liquid.

1,265,133. ROCK-DRILL. Thomas E. Sturtevant, Dover, N. J.

1,265,162. PROCESS AND APPARATUS FOR MAKING BOTTLES FROM PAPER PULP. Harry C. Ayerst, Seattle, Wash.



PNEUMATIC PATENTS MAY 7

1,264,712. ARIAL APPARATUS. Howard P. Tweed, Denver, Colo.

1,264,731. PNEUMATIC DIE-CUSHION. Carl Willers and Nils O. Laurin, Chicago, Ill.

1,264,737. WAVE-POWER APPARATUS FOR COMPRESSING AIR. Lemuel D. Woods, Boston, Mass.

1,264,843-4. VACUUM SEALING APPARATUS. Edwin Norton, Paget West, Bermuda.

MAY 7

1,264,939. VACUUM LIQUID-FEED DEVICE FOR INTERNAL-COMBUSTION ENGINES. Webb Jay, Chicago, Ill.

1,264,958. LIQUID-FUEL-FEEDING APPARATUS. Robert C. Mitchell, Mount Vernon, N. Y.

1,264,986. TIRE-PUMP. Charles P. Skublin, Detroit, Mich.

1,264,994. AIR STARTING MECHANISM FOR INTERNAL-COMBUSTION ENGINES. Henry W. Sumner, Winslow, Wash.

1,265,211. TIRE-PUMP. George Keith, Sheridan, Ill.

1,265,240. FORCE AIR-PUMP. Daniel M. Myers, Jefferson, Iowa.

1,265,450. FLUID-PRESSURE BRAKE SYSTEM. James A. Hicks, Cincinnati, Ohio.

1,265,482. GOVERNING MECHANISM FOR COMPRESSORS AND EXHAUSTERS. Sanford A. Moss, Lynn, Mass.

1,265,550. HUMIDIFIER. Albert W. Thompson, Fitchburg, and Edward W. Comfort, Winchester, Mass.

1,265,650. COOLING DEVICE IN MULTI-STAGE CENTRIFUGAL COMPRESSORS. Benjamin Graemiger, Zurich, Switzerland.

14,466. RE-ISSUE. PNEUMATIC STARTING DEVICE FOR INTERNAL-COMBUSTION ENGINES. Charles G. Eidson, Anniston Ala., Thomas Davis, Detroit Mich., and David E. Crouse, Auburn, N. Y.